Investigating Exploratory Testing in Industrial Practice

A Case Study

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ABSTRACT

Exploratory testing (ET) is an agile approach towards software testing. It is simultaneous learning, testing, reporting of problems and then generating new tests based on the learning. The aim of this thesis is to investigate exploratory testing in the industry. This thesis was proposed by Sogeti AB in Lund. Therefore the research questions were formulated and finalized according to their requirements and consent. Initially, a literature survey was conducted to study the different concepts of ET. After that a descriptive case study was conducted to investigate ET practices in an industrial environment. The research methodology used is qualitative. It comprises of ten semi-structured interviews with industrial practitioners including both ET testers and customers having different perspectives. The study explores the misconceptions about ET and also identifies its claimed pros and cons. The investigation also studies its suitability with different types of testing and its effective combination with other techniques. In addition to the interviews, a survey was conducted to further investigate and analyze our findings with a larger sample of 25 practitioners. A framework for a session-based exploratory testing as practiced by the industrial partner is presented as part of our results. ET has different opinions and it is hard to say whether they are misconceptions or not. The most prominent advantage of ET from the testers view point is utilization of tester's creativity and experience however, customers think the biggest benefit of ET approach is its ability to provide focused testing. The major disadvantage according to the testers resulted to be, difficulty in finding testers with appropriate experience, skill set and knowledge. On the other hand Inability to produce decision material was the biggest concern of the customers. The results also showed that ET approach was preferred to be used in combination with other testing techniques. Combination of Risk Based Testing and ET was reported to be used the most. ET was considered very suitable for situations where the testing requirements included learning of the system, time constraints and complementary testing. It was considered unsuitable for testing critical systems.

Keywords: Exploratory Testing (ET), ET Misconceptions, Exploratory Testing Framework, ET Industrial Practices

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Investigating Exploratory Testing in Industrial Practice – A Case Study

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Abstract— *Exploratory Testing (ET) is an approach for software testing that has gained attention with the rise of agile development practices. It can be viewed as simultaneous learning about the product, testing, reporting problems and designing additional tests based on the learning. However, there is a lack of research on the use and effects of applying ET. In this paper we present a descriptive case study of exploratory testing in an industrial setting. The study investigates the different meanings of the ET concept in literature, identifies its claimed pros and cons, misconceptions about it, its suitability for different types of testing and how it can be combined with other testing techniques. Our methodology is qualitative and includes ten semi-structured interviews with industrial practitioners, including both ET testers and customers with different perspectives on the technique. The methodology also includes a survey to further investigate and prioritize initial findings with a larger sample of 25 practitioners. Part of our results is a presentation of a framework for session-based exploratory testing as practiced by the industrial partner. The prioritization shows that the most prominent advantages of ET are better utilization of tester's creativity and experience while the main disadvantage is that it is harder to find testers with appropriate experience. We also found that customers view ET as a complementary testing strategy and that efficient ET requires tool support.*

Index Terms— **Exploratory Testing (ET), ET Misconceptions, Exploratory Testing Framework, ET Industrial Practices**

I. INTRODUCTION

The rapid change in the software development process, brings a lot of challenges to this field. In order to encounter these challenges, the companies search for more agile and cost effective methods [2]. This attitude is visible in all the phase of software development process. The methods, approaches and techniques of software testing have developed to adapt this change. The point of our investigation also falls in this specific area which is software testing, particularly testing techniques and methods. The term exploratory testing (ET) was first published by Cem Kaner in his book Testing Computer Software [4]. This approach has been used by the testers knowingly or unknowingly. But still it faces difficulties in being realized as an approach for performing effective software testing [2] [3]. One of the major reasons of ET not being realized - although practiced - is lack of scientific research. Therefore, ET seems to be a victim of a number of misconceptions [1] [7]. One of our main objectives in this study is to explore these misconceptions from different perspectives as very few studies are available regarding ET practices in the industrial setting [8] [26]. Due to which ET

approach is not very well perceived and considered to be ad hoc testing or error guessing [13]. ET also lacks support for its claimed benefits [26]. The concerns and lack of understanding regarding its adaptability and suitability makes this approach more alien to the industry practitioners [9]. Therefore, in order to improve an understanding of the ET concept and countering any skepticism related to it, a study presenting that how ET is being usefully implemented at some organizations can be very helpful. This thought has motivated us to investigate ET in an industrial setting. Views from a relatively large sample of industrial practitioners on different aspects of ET will also be helpful in understanding the concept and its practices.

The purpose of this paper is to study the method of exploratory testing practice and misconceptions related to it in the industry. It also aims to further verify the claimed pros and cons [7] of exploratory testing. The suitability and non adaptability of ET according to the industry practitioners is also discussed. The results mentioned in this paper can be useful for a number of future studies regarding exploratory testing.

The rest of the paper is structured as following. The next section presents the study design which comprises research methods used in this study. Section III presents the literature survey of ET and its related work. Section IV discusses the study execution which presents the results of the study. Validity threats of the study are discussed in section V followed by the discussion regarding our findings in section VI. Towards the end of the paper we state our contributions to the current state of the knowledge in section VII and suggest future work related to our study in section VIII. Finally the paper is concluded in section IX

II. STUDY DESIGN

In this section the overall investigation design is described in detail. Our research questions (RQ) were as following.
RQ1: What is exploratory testing?
RQ2: How ET is being practiced in a real time industrial setting?
RQ3: What are the misconceptions related to ET?
　a. From the testers/technical stand point?
　b. From the customers stand point?
RQ4: What are the advantages and disadvantages of exploratory testing?
　a. From the testers stand point?
　b. From the customers stand point?
RQ5: Which other testing methods ET can effectively be combined with?

RQ6: For which areas and test requirements ET

1. is best adaptable? Why?
2. is not suitable? Why?

In the subsequent sections we briefly describe the research methodology, the case company, selection of participants and finally the data collection and analysis procedure.

A. Research Methodology

A detailed literature survey was performed for the first research question. The methodology adapted for the rest of the research questions is shown in diagram below. Along with the methodology, the diagram illustrates the entire process of the research as well. The research process is divided in to four main processes that are literature survey, Sogeti case study, and survey in the industry then finally the process of drawing analysis, results and conclusion, marked as process 1, 2, 3 and 4 respectively. All the processes were performed sequentially as shown in the diagram. After the literature survey the research questions were formulated. The second process is the case study at the case company. We used a descriptive case study approach to answer the rest of the research questions. Descriptive case study is said to be an empirical inquiry that investigates a phenomenon within its real-life context [12]. In this research we intended to study ET in its real life industrial settings. Consequently, this gave us the motivation of using case study as our study approach. Our methodology is qualitative and includes ten semi-structured interviews with industrial practitioners, including both ET testers and customers with different perspectives on the ET approach. Along with the interviews, documentation analysis and an on-site participatory observation were also the part of the case study. The data collected from the case study was further used to design a survey which was conducted in the industry. The industrial survey is the third process as you can see in the diagram. The motivation of having a survey was to compare the results of the case study with the data from the industry and also to generalize our findings and conclusions. The survey was taken by a relatively larger sample of 25 testers in the industry. The last process of this research involved transcribing and analyzing the data from the case study and the survey, formulating the results and finally concluding our findings.

B. Case Company

The case company of our study is Sogeti AB in Lund. This research was proposed by the case company as well, therefore there was no criterion for the selection of the case company. But the case company was an ideal organization for conducting this research. Sogeti Sweden AB is a consultancy specializing in local professional IT services. They are present at 21 Swedish locations with a total of about 1 000 employees. The company delivers IT services in close co-operation with the clients. Their services include IT management services, professional IT services, development and integration of projects, testing, application management and infrastructure Services. Table 1 shows the characteristic of Sogeti AB. The case company has been exercising ET in its current form for

more than five years now. It also uses other testing techniques but ET played a significant role in the testing process.

TABLE 1 CHRACTERISTICS OF THE CASE COMPANY

Characteristics	Sogeti AB
Number of Employees	1000 in Sweden
Company Type	I.T Service Provider
Department we worked with	Testing Services Provider
Number of Testers At Sogeti Lund	20 Approximately
Type of Services Provided	Development, Integration and Testing of systems, applications and I.T infrastructure
Applied ET in its current form	Approx 5 years and more
Number of people Interviewed	10 (6 testers and 4 customer)
Formal training of ET Tester	Yes (introductory Training)

Sogeti also provides formal introductory training of exploratory testing to its testers. In this paper we have focused on investigating how exploratory testing is exercised in an industrial setting, the way it is controlled and managed.

C. Data Collection

The data for the case study was collected from three different sources for the purpose of data triangulation. The three sources were interviews, documentation analysis and finally on-site participatory observation. A survey in the industry was also conducted after the case study at Sogeti. Following is a short discussion about the data collection from each source.

Firstly, 10 semi-structured interviews were conducted at the case company. 6 interviews were conducted with the testers and 4 with the customers. As mentioned in table 2 in section II C, the interviews were conducted with 3 testers having skeptical views regarding ET and interviews with 3 testers having supportive views regarding ET. In case of customers, 3 of them were interviewed for ET supportive views and 1 of them was interviewed for ET skeptical views. 2 ET supportive and 1 ET skeptical customers were sent the interview questions by email as they could not allocate time for face to face interviews. There was extensive communication through emails to make sure the questions and answers were perceived properly. All the face to face interviews lasted for 60 to 90 minutes. The testers had testing experience varying from 2 to 6 years. The ET skeptical testers also had some experience of ET and had attended mandatory introductory training sessions for exploratory testing as well. The interview of each participant was conducted separately using the set of questions specifically designed for each type of participants as mentioned in table 2. These set of questions for each type were named study instruments. The interviews were
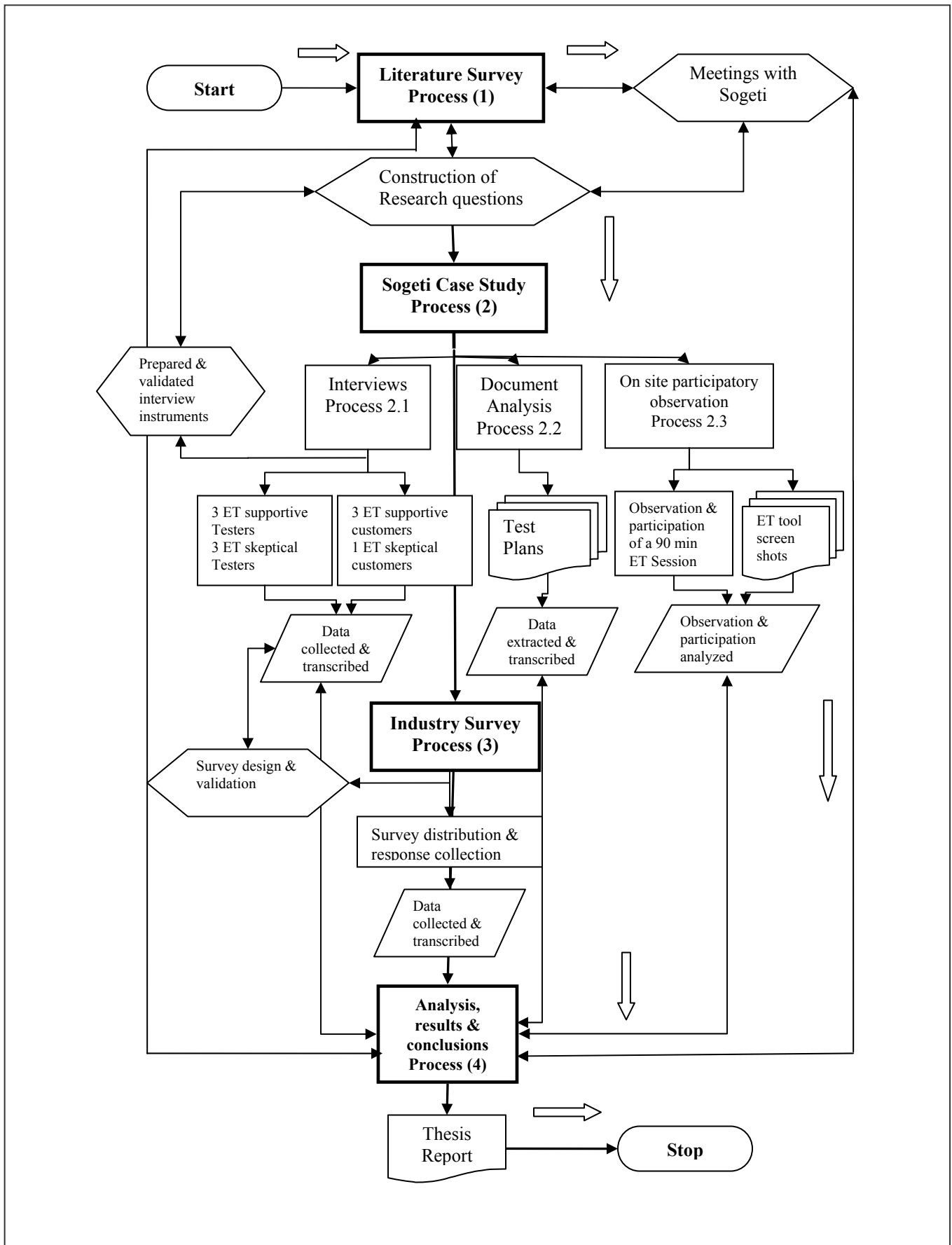
Figure 1 Research Methodology of the Study

conducted by two researchers. One of them asked the questions whereas, the other researcher made notes for the later analysis. The interviews were also recorded so that the notes taken manually could be clarified and complemented.

The second data source of the case study was the documents provided by Sogeti for conducting documentation analysis. The documents provided were the test plans for one of their projects. This was used to study their practices of planning, managing and controlling activities related to testing; specifically exploratory testing. We also studied the screens shot documents of the tool used for managing and reporting exploratory testing sessions.

The third data source of the case study was the information collected from the on-site participatory observation in 90 minutes exploratory testing session conducted at Sogeti. Initially the information obtained by observation was gathered by taking manual notes and using a tape recorder. Later, during the participation in the session, observations and personal experiences were recorder manually as well. It was like pair wise testing.

The final data source for this study was the survey in the industry. The survey with testers in the industry was conducted after the interviews at Sogeti. This was accomplished by using an online application for survey designing and collecting results called Survey Monkey[1]. It provided the facility for analyzing the results and constructing quantitative data into graphical and tabular form. The link of the survey was mailed to the testers on the Sogeti network and www.testzonen.se[2] which is a public Swedish test community.

The data collected from all these resources were transcribed and analyzed to find answers to the research questions.

D. Data Analysis

The information collected from the interviews in the form of manual notes and digital recordings were used for conducting data analysis. All the details in the notes were complemented with the digital recordings. The data from each type of interview was grouped together and was organized and separated based on the relevance to the research questions. The data collected for each research question was further analyzed for common, different and unique occurrences of the information. After that it was grouped manually and the clusters of the data were also identified and created manually. Although this process was manual but we tried to do it as accurately and systematically as possible. The data collected from the interviews was both qualitative and quantitative in nature. Once the information from the interviews was analyzed it was used for answering the research questions. The information was further used to create a survey for the industry practitioners.

The next step was analyzing the information collected from the documentation study. The documentation provided by

Sogeti was test plans for one their projects. We conducted analysis regarding its construction, contents, manner of expected execution and expected outcomes of the test plan. This analysis contributed in understanding the manner exploratory testing was planned and managed in the industry. It helped in answering the research questions more effectively.

After the documentation study we analyzed the data collected form the on-site participatory observation in a 90 minute exploratory testing session. The notes and digital recordings were analyzed and compared to the information provided in the interviews and documentation analysis. This cleared out any ambiguities in understanding the process of exploratory testing at the case company. It also provided information regarding the test environment, the tools used and the role of a tester in ET more clearly.

The final data analysis was of the data collected from the survey in the industry. The medium used for collecting data was survey monkey. We also used it to structure the data according to the survey questions and transcribe the quantitative data into graphical form. The data was then analyzed with the information collected from the case study at Sogeti to draw results and conclusions of our research.

III. RELATED WORK

The concept of exploratory testing has been acknowledged in software testing books since 1970 [2]. This approach has been exercised by the testers deliberately or unintentionally. But still it faces difficulties in being realized as an approach or activity for performing effective software testing [2] [3]. Exploratory testing is also termed as ad-hoc testing by industry practitioners mainly due to it being less structured as compared to traditional testing techniques specifically scripted testing [13].

Although this approach in its current state has gained focus recently but it was recognized way back in 1970's. Glenford Myers in his work realized exploratory nature of testing when working with error guessing technique [23]. However, in 1988 Cem Kaner, Jack Falk and Hung Q. Nguyen in the 1st edition of their book "Testing Computer Software" coined the terminology of exploratory testing [4][13]. They also disagreed that exploratory testing is ad-hoc or careless work. Instead they suggested that it is an intellectual activity that gives tester more control over the testing activity. Later in year 1999 ET was depicted as simultaneous learning of the system in parallel with designing systematic scripted test scenarios. The definition of ET has been offered by a number of practitioners [1] [2] [6] [7] [15] [16]. Looking at all the descriptions of exploratory testing given from 1970 to 2009 it is quite evident that the concept of ET has changed its perceptions from ad hoc error guessing technique to a thoughtful approach to fulfill a test mission. Most recently in 2009 James Bach has presented a definition of ET that is "*Exploratory testing is an approach to software testing that emphasizes the freedom and responsibility of each tester to continually optimize the value of his work by treating*

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[1] Survey monkey is an online application for conducting surveys and collecting results. For more details visit www.surveymonkey.com
[2] It is a public Swedish test community for details visit www.testzonen.se

learning, test design and test execution as mutually supportive activities that run in parallel throughout the project".

A. What is Exploratory Testing

After studying a lot of definitions of exploratory testing we can say that it is an approach which provides more value to the work of testers. As they are allowed to use their, knowledge, intellectual abilities, experience and testing skills to solve the problem at hand. This freedom increases their sense of achievement on accomplishing their tasks. According to Kaner and Bach [14] exploratory testing is simultaneous learning about the product, the market, the weakness of the product and the ways the product to could fail. This approach in contrast to traditional approaches and techniques of software testing does not follow the conventional coverage-driven test case design paradigm [7][14]. It does not rely on pre test documentation and test case designing. Based on this a Finish study [7] derived five characterizing properties of exploratory testing which are as following.

1. Tests are not defined in advance as detailed test scripts or test cases. Instead, exploratory testing is exploration with a general mission without specific step-by-step instructions on how to accomplish the mission.
2. Exploratory testing is guided by the results of previously performed tests and the gained knowledge from them. An exploratory tester uses any available information for testing. For example a requirements document, a user's manual, or even a marketing brochure.
3. The focus in exploratory testing is on finding defects by exploration, instead of systematically producing a comprehensive set of test cases for later use.
4. Exploratory testing is simultaneous learning of the system under test, test design, and test execution.
5. The effectiveness of the testing relies on the tester's knowledge, skills, and experience.

These characteristic can be helpful to realize in what ways and to what degree testing is exploratory testing. In 1999 authors[3] at the 7th Los Altos Workshop on Software Testing (LAWST VII) highlighted some of the common characteristics according to their views.

The concluded characteristics of exploratory testing were:
o Interactive
o Concurrence of cognition and execution
o Creativity
o Drive towards fast results
o De-emphasize archived testing materials

1) Advantages and disadvantages

According to our study, most of the conversed advantages of exploratory testing are based on its comparison with test case based testing or scripted testing approach [26]. We deem there is a need to study exploratory testing approach in terms

of advantages, in comparison to other testing techniques and approaches which are not based on scripted testing. According to our literature survey we have managed to encompass following advantages of exploratory testing which are also discussed in various resources [1][2] [3][4][7][13].

Exploratory testing approach offers many advantages. They can be summarized as following.

1. Thorough utilization of tester's skill.
2. Provides simultaneous learning
3. No or little test preparation
4. Efficient
5. Rapid feedback
6. Adapts well to changing project situation

Where there are many advantages of ET, it also has some disadvantages. The biggest disadvantage of ET is the misconception that ET is ad hoc [14]. However in the article exploratory testing dynamics [25] authors have argued against this misconception. They have presented applicable techniques to provide more structure to ET activity as well. Too much reliance on knowledge and ability of the tester is seen to be a disadvantage of this approach. It is believed that exploratory testing activity is more prone to human errors than systematic testing. Here rises the question that although rigorously tested, systematic testing also has chances to make human errors. The test case designer might miss out some functionality of the system and despite the system being systematically tested; those specific portions of the system would never undergo testing. Whereas, with exploratory testing approach, it is more likely that you would find such parts of the system during your exploration. Another disadvantage of this approach is the invisibility of test coverage. It is said that it is difficult to track the progress of the product and to know how much testing has been done [1] [7]. The coverage issues are also related to the planning and selecting of what needs to be tested with exploratory testing. The study [7] shows that it is difficult to prioritize what needs to be tested, especially when you have time constraints. In this case, you have to look for expert testers in that domain to produce adequate testing. Reproduction of defects is also seen as a disadvantage of this approach. In exploratory testing it is hard to reproduce the bug again in order to report it. This process sometimes takes a lot of time. But appropriate test session logging can solve this problem to a great extent as suggested in Session based test management [9].

Exploratory testing approach is highly situational [1] and any testing technique can be used in an exploratory manner. However to maximize the productivity and to have more control over the testing process, exploratory approach is exercised in the following styles.

B. Free Style Exploratory Testing

Free style exploratory testing is a focused wandering of the system under test without following any test plans or specification. The utmost purpose is to find the bugs and report them at the end of testing. Not following predefined test procedures does not mean unmanaged testing. Regarding this,

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[3] Brian Lawrence, III, Cem Kaner, Noel Nyman, Elisabeth Hendrickson, Drew Pritzger, Dave Gelperin,Harry Robinson, Jeff Payne, Rodney Wilson, Doug Hoffman, James Bach, James Tierney, Melora, Svoboda, Bob Johnson, Chris Agruss, Jim Bampos, Jack Falk, Hung Q. Nguyen and Bret Pettichord

Bach talks about few guidelines for managing exploratory testing [13] which are as following.

Free style exploratory testing can be executed by assigning charters to the testing team. The charter is allocated by the test lead and contains information about what is to be done. The testers are then responsible to accomplish their charters. They design, execute and repot their charters. This approach of free style exploratory testing is called managing by delegation [13]. It tries to apply individual test management on the testers. By doing this testing process becomes auditable. To further make this process more controllable; frequent meetings can be conducted to discuss the progress of testers and problems they experience [1]. Test reporting in this style can be verbal or written. Managing exploratory testing by delegation helps in assessing the individual performances of the testers. It also helps in understanding the capabilities and expertise's of the testers involved which can aid in assigning further tasks.

Another way of managing free style exploratory testing is managing by participation [13]. The test lead participates in the testing activity like other team members. The approach boosts up the efficiency of entire team members, as the lead is continuously directing the test strategies and conveying his expectations from the team members. The active participation of the leader helps in prompt decision making during testing. His experience tends to relegate the potential of uncertainty and inefficiency of testing using an exploratory approach.

Free style exploratory testing term creates a misconception of being unmanaged and merely playing with the system under test. Whereas free style exploratory testing utilizes the strengths of this approach the most [1],[13]. In this style the testers are likely to use their intellectual powers without any disruption caused by managing or mechanizing the testing activity. This enables the testers to design right tests at the right time. This would facilitate in finding imperative problems promptly.

C. Session Based Test Management

Session based testing (SBT) is interchangeably used with session based test management (SBTM). This approach has recently been introduced by Jonathan Bach [9] to provide more structure to exploratory testing or to unscripted testing in general. In this approach a test session represents a single work unit. Each session has a mission or charter to accomplish. To fulfill the charter an uninterrupted time constrained session is held by the testing team. The suggested time frame for SBT is 90 minutes but it is not a compulsion, as stern time limitation can affect quality of testing [9]. This time frame comprises testing only. It excludes the tasks related to testing process such as, set up time or bug reporting. In SBT the entire session is broken down into three types of tasks that are

1. test design and execution
2. bug investigation and reporting
3. session setup

These are called task breakdown structure "TBS" metrics.

Test design and execution tasks are related to the inspection of testing product of project to locate problems. Bug investigation and reporting tasks are activities related to understanding and reporting of the bugs or issues. Session setup tasks are all those activities that are related to setting up an appropriate test environment e.g. configuring equipments, reading manuals or writing session report. By maintaining an account of these sessions and the missions accomplished by them we can keep track of what is being done and achieved. This is done by maintaining session reports. These session reports are generated by the information provided in the session sheets by the testers. After the session ends the test lead or test manager conducts a "debriefing" session. This is to increase the visibility of a test session mainly with the test lead or test manager. The contents of debriefing session are:

1. Past: the events occurred in the session
2. Results: the achievements in the session
3. Outlook: what more is required regarding the current issues?
4. Feelings: what are the feelings of the tester about the session

SBT method provides the ability to predict the number of sessions required to fully test the system [9].By doing this the progress of the entire testing cycle can be predicted and an approximation of how long testing would take can be made.

IV. STUDY EXECUTION AND RESULTS

This section presents the analysis and results of the data collected from the case study at Sogeti and survey in the industry. These analysis and results are divided into subsection based on the research questions. Initially we present the results regarding the industrial practices of ET. Then we highlight the misconception related to this approach. After that explicit pros and cons of ET according to the industry are presented. The subsequent section discusses the effective combination of ET with other testing techniques in the industry. The final section presents the area and testing requirements where exploratory testing is adaptable and where it is unsuitable.

A. ET Practices in an Industrial Setting

This section discusses the purpose of using exploratory testing at Sogeti. The data was collected though interviews at Sogeti and sorted to find out the reasons for using ET. The reasons found are further reported and discussed here. This section also illustrates the way ET is exercised at Sogeti. Data for understanding the methods of ET at Sogeti was collected from interviews, documentation analysis and on-site participatory observation. The collected data was analyzed to chalk out all the activities of an exploratory testing session and the manner they were exercised. The identified activities and the manner they were excised were used to construct a framework to show ET process at Sogeti.

1) Purpose of Using Exploratory Testing

The interviewees at the case company stated various purposes for using exploratory testing. We listed all the

purposes reported by both the testers and the customers. In order to know the importance of the purposes we calculated the number of occurrence for each purpose in the interviews. Table 3 below shows the list of reported purposes and their number of occurrence.

TABLE 3 PURPOSE OF USING ET AT SOGETI

Purpose Number	Purpose	Number of Occurrence
1	Learning of the system	5
2	Intelligent decision making	3
3	Targeted testing	6
4	Negative testing	2
5	Smart testing	4
6	Intensive testing	3
7	Freedom to re-plan, refocus and reorganize	3
8	Effective usage of testers abilities and time	4
9	Cross functional testing	2

According to the results mentioned in table 3, the most important purpose of using exploratory testing reported was targeted testing. It was mentioned by all the customers in the interviews. The reasons mentioned were that it was easy with exploratory testing to target specific areas of the system under test. The interviews also stated that it was very helpful in scenarios when you are not aiming for extensive testing of the product. This was mentioned by all the testers and the customers at Sogeti. The second most important reason was learning of the system. This is also one of the identified benefits of ET mentioned in the related work.

Other purposes reported were intelligent decision making, smart testing and most importantly appropriate usage of tester's time and abilities. ET was also reported to be very effective in providing intensive testing, as there is very little or no reliance on the predefined documentation therefore, most of the time is utilized in performing the actual testing. Here when said " no predefined documentation" does not mean that ET activity is not planned it means that while this activity is being carried out there is no step by step instruction to follow as it is done in test case based testing. Hence exploratory testing according to participants of this study provides the freedom to re-plan, reorganize and refocus. This attribute of exploratory testing is highly appreciated in industry as it allows them to think outside the traditional approaches.

Sogeti is mainly using exploratory testing in the projects where extensive user interaction is involved such as testing application designed for mobiles. Here they refer ET as smart testing. Other than that exploratory testing is also being used for system cross functional testing for one of their customers. Several individual systems work together as one system. When ever a defect or problem occurs, all the systems are tested to locate the problem. Sometimes, each system individually is not producing any defects or problems it is the cross system functioning that causes problems. Exploratory testing in this scenario is being very effective for testing and locating what is between the systems and where the problem is arising. The reasons they find exploratory testing more

effective in this regard, is the fact that test case based testing would require a very large number of test cases to locate such problems. Another fact is that the probability of newer types of bugs arising is high. In such case test case based testing would be less effective and more time consuming. Moreover it is impossible to design test cases for unexpected bugs. Hence exploratory testing seems to be the most appropriate choice to utilize testing and tester's time efficiently and effectively according to the testers who participated in the study.

In our study we also figured out the purposes of not using exploratory testing mentioned by the interviewees. The ET skeptical testers detailed that the reasons for not using ET were

1. Customer is not satisfied / does not want to use ET
2. ET is not appropriate for the system type (such as critical system)
3. Their work is not considered credible

The testers although agreed that ET was being used at the individual level for individual task. But the above mentioned reasons abstained testers from using ET. The customers however, stated that they did not use exploratory testing because they were uncertain about the approach and the results. According to our observation this was mainly due to the fact they did not have enough knowledge about the approach and its pros and cons. Therefore they seemed hesitant in using the approach. On the other hand customers working with critical systems said that they sometimes use ET to further complement their testing. But did not use ET approach as a main technique for testing there product.

2) Exploratory Testing Framework

One of the aims of our study was to find out and highlight the procedure through which exploratory testing is being performed in an industrial setting. In order to do that, we created a framework of ET based on our findings at Sogeti. There for the framework is called Sogeti SBET. The prime motive of constructing this framework is to give an idea how ET is performed in the industry. The framework is not created by Sogeti, but all the activities in the framework are being exercised there. The construction of the "Sogeti SBET Framework" is based on data from the interviews, documentation analysis and on-site participatory observation of an ET session. Sogeti follows the instruction of SBTM provided by Jonathan Bach as mentioned in [9] but have customized and structured it according to their needs. This is said to be producing more organized, accountable and traceable results.

a) Construction of the Framework

The data collected from previously mentioned sources was organized to identify all the activities of a testing session in order to accomplish a mission. The activities were further categorized based on the TBS metrics [9] discussed in section III C. After categorizing the activities, the order of occurrence

Prerequisites of phase 1:
• A complete test plan for the project or product under test is designed
• The test plan details the project or product objectives
• The test plan details the test strategy based on the product risk analysis
• Have formulated test goals during risk assessment of the product

Phase 1: Test Session Planning
• Test charter extracted from the Master test plan of the project
• Test mission extracted from the charter
• Scope of the test mission is decided
• test goals are set based on the risk assessment conducted prior in the test plan
• Areas to be tested are identified
• Allocation of recourses for the testing session e.g. time and number of testers
• ET tool is used to log the details of each mission
• Information regarding every test mission is stored against its ID that is mission ID
All the details like mission submitter's information, test type, mission date, pre mission conditions, mission date, mission subject and mission description is stored
• Session time is setup usually 90 minutes

Phase 2: Test Session Execution
• Allocation of session tasks to the testers based on expertise
• Testers design and execute tests based on their tasks
• Testers log each and every step performed in the session in the data base
• Testers make note of the things they come across which are not in the test mission
• Log the reasons for deviating from the test mission (if doing so)
• Debriefing the entire activity immediately after the session ends

Phase 3: Test Session Controlling and Tracking
• Controlling the test session activity by logging each step in the database
• ET tool is used to log the details of each session
• After the test session all the testers have to fill out the mission note which consists of information regarding test logs, Accessories used or required, Issues, conclusions, Usability comments and future testing.
• The ET tool also stores information regarding the test hardware and software. The time spent to setup the test mission, time spent on testing and then time spent on bugs
• Mission reports are further generated based on the information provided above.

Figure 2: Sogeti SBET Framework

of each activity was analyzed. After that we divided entire test session into phases. These phases were inspired by the TBS metrics as well. The activities that were already categorized according to the metrics were added to the corresponding phase. But during our analysis we observed some activities which were important to perform, before the first phase of the framework. These activities were therefore said to be the prerequisite of the framework. Figure 1 shows the Sogeti SBET framework. All the activities of a session are spread over three different phases. The three phases are:

o Test session planning
o Test session execution
o Test session controlling and tracking

Following are the meanings of few terminologies used in the framework.

Charter: The test mission and area to be tested
Mission: what is to be accomplished in the test session?
Test plan: It refers to the entire test plan of the project
Test strategy: what will be tested and when
Test type: usability testing, Functional testing

b)   Prerequisites of Phase 1

There are few pre requisites that need to be fulfilled before the test session such as, product or project test plan. This test plan contains the detail of how the project or product would be tested. It comprises the details regarding the testing objectives of the project, details the scope of testing, preconditions for testing and assumptions made in the plan.

The plan also contains details regarding test strategy based on the product risk analysis. The product risks are determined in cooperation with the client and the other parties involved. Each risk from the product risk analysis is divided into a class. The risk class determines the urgency of the test. Risk class A is the highest risk class and C the lowest. The test strategy is subsequently focused on covering the risks with the highest risk class as early as possible in the test project. During the risk assessment the test goals are also formulated.

The test plan also discusses the roles and responsibilities of the people involved in the project testing. Description of the test environment and types of test tools that would be used are detailed as well. The test plan also includes plans for test management which involves management of test process, test infrastructure and test product. The purpose of mentioning the project test plan in detail is the fact that effective exploratory testing requires good and comprehensive project test planning as any other testing activity does. This enables the testers to take the appropriate decisions while creating exploratory testing charter.

c)   Phase 1: Test Session Planning

When planning exploratory test session; the process is setup according to the project context. That means the charter of the exploratory testing session is decided based on the information in the project test plan. The charter includes the details regarding the test mission and the area to be tested. Whereas a mission is the description of what is to be done. In this phase the test mission and the scope of the mission is

decided so that the testers have clear testing goals. This is very important to keep the testers focused so that they can accomplish the mission of the session. Prior to the start of the session resources are assigned to the test session such as time and number of testers required to accomplish the test mission. The mission, when planned, is submitted in the exploratory testing tool that Sogeti has built to aid them to manage and control exploratory testing activities. This software is called ET tool by Sogeti. Every mission is unique and has its ID. All the detail regarding the mission subject and mission descriptions is mentioned. Mission description comprises of details related to "Planned technique" and "Planned checklist". Planned technique contains information regarding *what is to be done* such as functionality verification and usability test. Planned checklist on the other hand has details regarding the area that is to be tested. An ideal test session time duration as suggested by Jonathan Bach [9] is normally followed but not very sternly as accomplishment of the mission is at a higher priority.

d) *Phase 2: Test Session Execution*

The team lead assigns the tasks to the testers normally based on their expertise. When the session is appropriately setup the testing time starts. The session setup time is not included in the testing time. During the testing time testers design and execute test cases at the same time and log each and every action they perform using a logging tool called *LogCat[4]*. There is always a possibility that during the exploration testers would find issues which are not in the scope of the test mission. In such situations they make notes of their findings and add them to the database. The testers make notes using ET tool. In some scenarios if the tester comes across a serious issue which needs to be resolved in the same session, he/she provides complete reasoning for deviating from the test mission. The tester also reports if certain issue requires another session. When a testing session is terminated, a bug report is prepared. The testers note the test logs, issues, conclusions and future testing in the ET tool. Shortly after the session has ended the tester and the test lead have a debriefing session where they discuss the findings of the test session, test design techniques used and also discuss the issues which have resulted in a need of new test missions.

e) *Phase 3: Test Session Controlling and Tracking*

The test session controlling phase overlaps with the test session execution phase as all the logging activity is being done simultaneously with the test designing and execution. Test session mission notes are made in the ET tool once a session expires. These notes consists the description regarding the test logs. The accessories used during testing are also reported. This is done to provide information about the testing

environment so that in future, if the tests are repeated they may produce different results if different accessories were used. The issues found during testing are also reported in detail with their description and severity. After that the conclusions drawn by the testers are noted and the tester provides the usability comments regarding the product. Finally the tester provides the notes regarding any future missions if required. The information regarding the time spent in the session is also recorded. Such as time spent on session setup, time spent on testing and time spent on bugs. The detail regarding the hardware and software used is provided as well. The mission reports are then generated based on the information provided above. These mission reports are further used to show the customers the progress and accomplishment of the testing project. A sample test session report is appended in the appendix G which is in the Appendix part of the report. This session report does not belong to Sogeti as they did not provide us with one. It is sample session report provided by [9]. It will help to understand what a session report looks like and what are its contents in general.

3) *Discussion regarding the framework*

In this section we have discussed the framework with respect to its purpose of creation, usage, people involved and comparison with the SBTM by Jonathan Bach [9].

(1) Purpose of Construction

The Sogeti SBET framework is to show a practical example of exploratory testing in the industry. This framework shows how effectively ET approach is being carried out in the industry in a structured and manageable way. This framework also highlights the activities of an ET session and depicts the kind of tool support required for effectively controlling and tracking ET sessions. Another prime motive of constructing this framework was to show that exploratory testing in not ad hoc testing neither it is being applied in an ad hoc manner in the industry. It is an approach which is structurally applied in a testing process to obtain specific and desired result. It also shows that the extensive amount of logging through out the process is sufficient enough for showing the accountability of the process. The reports generated can be used for decision making as well. However, the customer we interviewed at Sogeti required that ET should be able to produce concrete decision material showing various statistics of the entire testing process. This would increase its creditability.

(2) Usage

A testing project which is under test using ET can have a number of testing sessions. This framework can be repeatedly used for every test session with a unique mission. The prerequisite phase of the frame work needs to be executed only once for every testing project assuming that the test plan is designed for the entire testing of the product or project. The three phases are to be executed in their respective manner. However, phase two and phase three have few overlapping activities as mentioned previously. Sogeti SBET is currently based on the activities at Sogeti but it can be easily

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[4] LogCat provides a mechanism for collecting and viewing system debug output. Logs from various applications and portions of the system are collected in a series of circular buffers, which then can be viewed and filtered by different LogCat commands.

customized for any other industry according to their activities assuming that typical core activities of SBMT are being exercised. Tool support is an integral part of this framework and cannot be effectively applied without appropriate tool support for logging and reporting the session activities.

(3) Roles involved

The people involved in the testing session are the testers and the test lead. There are no roles specific to a particular phase only. A tester or a group of testers select the mission from the available mission list of the testing project and start conducting the testing session. However the involvement of the test lead is important at debriefing. On the other hand, the involvement of the test lead in all phases depends on the complexity of the mission at hand. The selection of the testers is however based on their knowledge about the domain and experience. The testers at Sogeti are provided introductory training of exploratory testing.

(4) Customizations of SBMT

The Sogeti SBET framework has all the characteristics that are detailed by Bach [9] in the SBTM. These characteristics have been discussed in section III C. Therefore we can state that this framework fulfills the description of SBT. Following are customization made by Sogeti which differentiates it from SBTM by Bach [9].

o The SBT process by Bach lacks in providing traceability to the material which is used in planning the test session. Whereas, in Sogeti SBET framework the traceability is visible. Where the test charters comes from, based on what information the missions are created, on what basis the test goals are set. All such information is easily visible and traceable.

o Sogeti has developed a customized tool to support to control and track their ET session. System log is being stored in the database continuously. This is to log all the actions of the testers and also to ease the reproduction of the bug if required. Whereas in SBTM, session sheet does not maintain this extensive logging of the entire ET session. Sogeti uses ET tool and LogCat for controlling, tracking and reporting a test session. On the other hand SBTM uses a tool written in Perl that scans the information on the session sheet and produces different tables and metrics [9].

B. Misconceptions Related to Exploratory Testing

This section presents the results of the investigation to highlight the misconceptions related to ET approach. Initially, misconceptions were investigated in the literature. The information from the literature analysis was verified in the interviews at Sogeti. New information from the customers and testers was also collected in the interviews. After that the raw data was analyzed and structured into three different categories. First category was "general" which depicts the common misconception between testers and customers. Second was "tester" which shows the testers perspectives and

third was "customer" which presents customers perspectives. The categorical distribution was further used for discussion and analysis.

During our investigation regarding the misconceptions related to ET approach we found a number of illustrations in the literature that stated some of the misconceptions related to exploratory testing such as in [13][14][26]. We enquired the stated misconception in the interviews and gathered new opinions as well. This helped in understanding the rationale behind different misconceptions from the perspective of testers and customers. According to the best of our knowledge, misconceptions related to ET approach from the customer perspective have not been discussed prior to this. Table 3 shows the misconnections related to each category and the number of times they were reported in the interviews as Sogeti.

TABLE 3 MISCONCEPTION RELATED TO EXPLORATORY TESTING

Perspective	Misconceptions	Number of people reported
General	o ET is a technique rather than an approach o More prone to human errors	6 out of 10
Tester	o Testers work is not valued and considered playing. o Customers do not prefer using ET approach o ET does not produce results to satisfy the customers for taking decisions based on the reports produced.	3 out of six testers
Customer	o Test Coverage o Visibility of testing process progress o Work products and decision material are lack statistics for decision making	3 out of 4 customers

The discussion related to the misconceptions in the following section also refers to the results from survey conducted in the industry.

1) General Misconceptions

The prime and most general misconception exploratory testing seems to face is that it is considered a technique. Exploratory testing is an approach; this is well known in the industry but not very well perceived and used in this manner in the industry. The reasons for this misconception was analyzed to be the fact that traditional techniques go way down to the roots of testing and have been used for a very long time. ET being relatively new phenomena and moreover being an approach than a technique has created a lot of confusions regarding its adaptability. Industry is very much use to the traditional techniques and find it difficult to adapt an approach that has no step by step structure and very few experienced people available in the industry. This opinion regarding the misconception is based on the results from the interviews. Most of the testers were sure of ET being an approach but some of them were not. It was also seen that the testers who adapted ET as an approach were relatively more confident and benefiting from it. Whereas, the testers who compared ET with other structured testing techniques were

less satisfied with exploratory testing and expected it to be more structured and were reluctant to use it. This shows that there is confusion regarding the correct perception of ET.

The customers to some extend were also found a little provoked towards the literature available regarding ET being insufficient and expressed that "it seems easy to move away saying ET is an approach not a technique". They demanded more insight and statistics of what difference ET being used an approach can make in the industry. This indeed leads to investigating and creating work products according to the customer's requirement for their satisfaction and understanding.

Another common misconception related to ET approach is that exploratory testing is more prone to human errors. According to one of the tester in the interviews "the simplest answer to this misconception is that every activity whether ET or structured testing which involves human interaction is prone to human errors". A number of studies are available regarding creating effective and error less test case in structured testing which it self explains that human errors occur in structured testing as well. This misconception or we would rather call it opinion lacks empirical evidence for stating whether it is a disadvantage or a misconception related to ET approach. Itkonen's work [8] discusses the efficiency of ET related to structured testing but we also need studies that shows which one of them is more prone to human error as well if the acceptability of this approach depends on such evidences.

2) Misconceptions from the Testers' Perspective

The ET supportive testers interviewed at Sogeti reported that biggest misconception related to this approach is that the results achieved by ET are unable to satisfy the customers. This opinion has also been stated at a number of instances in the literature such as [1] [2]. The reason the ET supportive testers called it a misconception was based on the fact that their customers were satisfied with the results produced. However they stated that it is hard to convince a customer with no or little knowledge regarding this approach but once they start seeing the benefits and results they consider this approach very valuable. They also added that ET approach is highly situational dependent therefore; the customers who know when and where they can use exploratory testing benefit more form it. In order to know more about this opinion to state it a misconception or not we interviewed Sogeti customers as well.

tangible reporting to improve and aid their decision making process. They also reported that the current reports created by ET were not alone sufficient for making decisions regarding the product under test. Figure 3 shows one of the results from the survey that investigates the similar issue from a larger sample of testers in the industry. It also showed that 13 of 25 testers which is 52% agreed that results produced by ET were sufficient to satisfy customers. Whereas, only 1 of 25 testers which is 4% of the testers reported that the results produced by ET were not sufficient enough to satisfy the customer. The remaining 11 testers which is 44%, stated that the satisfaction of the customers was highly situation dependant and involves other aspects such as type of project and expected results. Therefore, according to the current findings we can say that this is a misconception. But there is a need to further verify this with a larger sample of testers and customers as well.
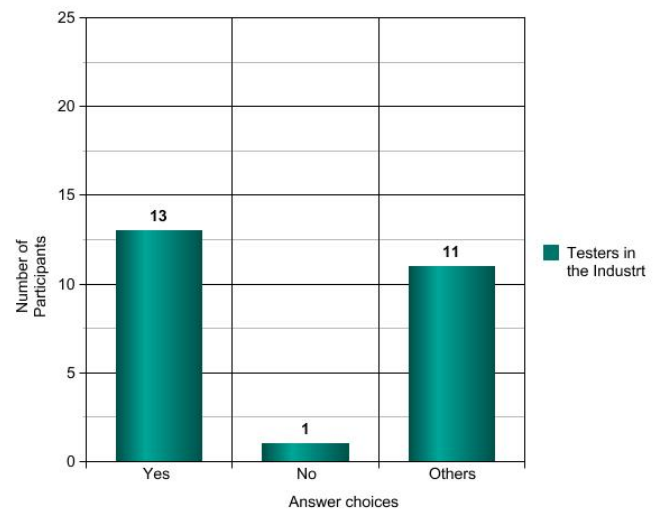

FIGURE 3: RESULTS FOR THE ABILITY OF ET TO SATISFY THE CUSTOMERS

During our investigation we gathered information about the reasons for not using exploratory testing in terms of importance. The results are mentioned in table below.

The reasons mentioned in the table were congregated using the available literature in [7][13][14] and verified in the interviews at Sogeti. According to the table the most important reason for not using exploratory testing mentioned by 8 out of 10 participants is that "customers" do not want to use ET approach. 6 out of 6 testers reported this to be the most important reason where as only 2 out of 4 customers agreed that they are not willing to use the approach.

Reasons	Not Important	Important	Very Important	Most Important	Total
Shortcomings of ET approach	3	7	1	0	10
The customer is not satisfied with using ET approach	0	1	1	8	10
The type of system under test	0	3	5	2	10
Lack of knowledge about ET approach	0	4	6	0	10
Little knowledge about benefits and effects of ET	1	5	3	1	10
ET concept is new and lacks in depth research.	2	4	4	0	10

TABLE 4 REASONS FOR NOT USING EXPLORATORY TESINT BY SOGETI

The ET supportive customers reported that it is a misconception and that they are satisfied with the results. However they were not very satisfied with the type of decision material produced by ET. They wanted more statistical and

This is also one of the misconceptions regarding ET that customers do not want to use exploratory testing because they think it is not a reliable and structured approach. But during the interviews when this opinion was further investigated

customers reported that they refrain from its usage not mainly due to the credibility of the approach but it is because they do not find experienced exploratory testers in the industry. They also mentioned that at times the type of the project is not very suitable for ET. Whereas in case of testers, the ET supportive testers interviewed had similar thoughts as the customers but ET skeptical testers had this misconception that ET is not a very well received approach by the customers therefore they should not adapt it. But as mentioned by the customers that it is difficult to find experienced and skilled ET testers therefore the lack of knowledge and experience in the testers seems the reason customers do not want them to use ET approach. However further studies are required to investigate the customer perspective in more detail to find out the main source of this misconception.

Another problem testers reported in the interviews was regarding the value of their work. They said that there are misconception regarding the value of their work as it is considered to be playing with the system when performing exploratory testing. This misconception has also been mentioned in the literature [1] [2]. The testers reported that the cause of this misconception lies in the fact that ET is not as structured as test case base testing. It also does not highly rely on step by step instruction for testing which gives the impression that it is conducted in an ad hoc manner hence the work being done is not valued moderately. But on the other hand the testers who had such experiences also reported that when the customers see the results of their work they are convinced. We also interviewed the customers regarding this issue and they agreed that the work of the testers using ET approach is not as transparent as the work of testers using test case based testing. Therefore, when there is a requirement to have a better transparency of the testing process, ET approach is not considered to be a good choice. The SBTM in this case solves the issue of transparency to a greater extent as each action of the tester is logged. But in order to satisfy the customers there is need to make the work of the tester more transparent so that it is valued appropriately.

3) Misconceptions from the Customers' Perspective

The facts regarding the misconception form the customer perspective were composed using response from four customers at Sogeti, who participated through interviews. The main misconception of exploratory testing stated were related to

- o Test Coverage
- o Visibility of the progress of testing process
- o Work products and decision material

The customers in the interviews reported that they were uncertain regarding the test coverage when using ET and they said that only certain parts of the system could be tested using ET. The testers at Sogeti did not agree with the opinion of the customers. They mentioned that it is possible to check the entire system using ET. However they agreed to the fact that ET is a time consuming and does not have experienced testers therefore not everything could be tested. Due to this fact it is

wise to prioritize the test requirements and areas of the system that need to be tested. The tester also added that testing can never said to be complete. Intelligent testing is to define a good enough testing scope based on the reasons the testing is being performed. Even with scripted testing, after running thousands of test cases it cannot be said for sure that the system under test has been tested completely and with assured quality. Although test coverage issue is reported to be a misconception of the customer by the testers at Sogeti they study by Itkonen [7] shows that this issue was mentioned by a number of testers in three different case companies as a shortcoming of ET. However the issue reported by the testers in Itkonen's study mainly refers to the difficulty in planning and prioritizing what to study with ET. Therefore more research is required to actually prove weather it is a misconception or shortcoming of ET.

The customers at Sogeti reported that the progress of testing was not visible when using exploratory testing. They reported that it was difficult for them to analyze how much testing is done and on which area of the system. To find whether it is a shortcoming or misconception, we analyzed the views of the testers and the customers at Sogeti. The biggest reason analyzed for this misconception is the mind set of the customers. They prefer to see numbers and figures as early as possible in the testing activity so that they can perform analysis. Using traditional techniques such as scripted testing, customers can see the test progress by seeing the number of test cases executed so far. But in case of exploratory testing, number of sessions or reports regarding bugs and issues do not give the same result. Hence, the customers take the difficulty to see what and which area has been covered at a given point of time as a shortcoming of ET. The Sogeti SBET framework addressed the problem to a certain extent. The test plan contains the test objectives and to meet those objectives certain goals are defined. These goals are further used to create missions. The number of missions required to accomplish the test goals can be used as a metric. Consequently, the progress of the testing process would be visible. We can also calculate the amount of time required to complete the testing process using this metric. However, currently it is hard to say whether the progress of testing process issue is a misconception or a shortcoming. We need evidences from a larger sample of customers and testers to verify whether it is an issue or a shortcoming.

Another misconception regarding exploratory testing originates from the customers. The misconception is related to the work products and decision material produced while using ET approach. The customers at Sogeti stated that mere reporting of bugs, issues and number of exploratory testing session does not provide material that can be used for decision making. Therefore currently they complement this material by using reports produced by other testing activities as well. They required that results provided should be substantial enough to take decisions solely based on them. Whereas the testers at Sogeti mentioned that their customers were very satisfied with the results produced. We analyzed that this satisfaction was

due to the fact that Sogeti customers knew why and for what they were using ET approach. They also knew the expected results. Therefore, the ability of ET to produce desired result lies in knowing the rationale of its usage and expected outcomes [13].

Another reason behind this misconception could be the fact the tester's knowledge and creativity has not been exploited to the extent that they could be able to generate credible and professional reports of their work to satisfy the customers. Their entire creativity and skill is utilized to deign test cases and structured testing makes it easy to create structured reports. Whereas in ET, designing and execution of test cases happen simultaneously therefore, everything cannot be detailed explicitly. A lot of information remains with the tester in tacit form. Test reporting in this case becomes more of a creative task that requires good skills. To create such reports hands on experience with exploratory testing is the key.

Further detailed studies are required to distinguish the misconceptions from the shortcomings regarding ET approach.

C. Advantages and Disadvantages of Exploratory Testing

The results of the investigation regarding the pros and cons of exploratory testing are presented in this section. Initially a literature survey was conducted to find out the redundantly stated pros and cons for ET. Table 5 enlists the identified pros and cons of ET in the literature.

TABLE 5 LIST OF ADVANTAGES AND DISADVANTAGES

Advantage of Exploratory Testing
Utilization of testers creativity
Utilization of testers experience and knowledge
No pre designed documentation to follow
Simultaneous learning of system under test
Minimal or no preparation before performing testing
Focused testing
More effective in terms of detecting important defects
Rapid feedback
Adapts well in rapidly changing situations
Disadvantage of Exploratory Testing
Difficult to track the progress of testers
Difficult to track the progress of test session
Traceability issues
Coverage issue (only selected parts can be tested)
More prone to human errors
Difficult to find testers with appropriate experience, skill set and knowledge
Less accountable and auditable

These pros and cons were verified through interviews at Sogeti and then a survey in the industry by using the 100$ test method. The motive of conducting the survey was to generalize the findings. The data collected from the tests was then transformed into graphs to draw conclusions regarding the investigation. The motive of this study was to present explicit pros and cons of ET from the customer and testers perspectives in the industry.

1) Advantages of Exploratory Testing

This section presents the results of the 100 $ test for advantages of exploratory testing by Sogeti testers and industry testers.
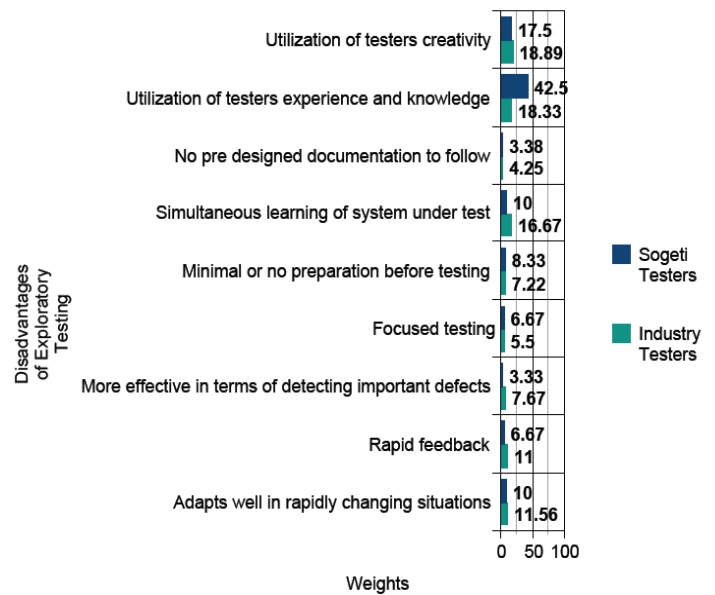

Figure.4 100 $ Test Results of Sogeti Testers and Industry Testers for the Advantages of ET.

Figure 4 shows the results of the tests for advantages of ET. Six testers from Sogeti and 25 testers from the industry took this test. X axis in the graph depicts weight and Y axis lists the perceived advantages of ET. According to the testers at the case company, the biggest advantage of ET is appropriate utilization of testers experience and knowledge. Second biggest advantage is the utilization of tester's creativity. The benefits ranked third are simultaneous learning of the system under test and ability to adapt well in the rapidly changing situations. These advantages are the claims mostly made by a number of practitioners in the industry [1][2][13]. Therefore, the results confirm that these are not just claims or perceived benefits rather they are explicit benefits of ET. This quantitative data also matches our findings during the interview session. Apart form these benefits, the testers reported that ET has added value to their work description. They stated that doing exploratory testing was more effective usage of a tester's time and intelligence as compare to traditional testing techniques. It brings more fun, freedom and responsibility to there work as it challenges the intellect of the tester. ET increases the sense of accomplishment in testers when they are performing well specially in time constrained situations. Analyzing the biggest advantage stated by the testers at Sogeti we can infer that ET is an intellectually engaging activity for the testers. They are interested in effective and efficient use of their skills, knowledge and experience. As mentioned above by one of the testers that "it brings pride to the work". The advantage "no pre designed document to follow" has been assigned minimum weight. Here we can infer that ET activity does rely on some information to be followed, such as mission description, session goals and area to be tested if not step by step instruction for testing. This shows that ET is not unstructured, unprepared or merely playing with the system. Another noticeable result is that the perceived advantage "finding

important defects quickly" was assigned minimum weight. But according to the data collected from the interview it was relatively of more importance but highly situation dependent. Being highly situations dependent can be the reason for being assigned minimum weight in this test. The experiment by Itkonen [8][26] also depicts that ET is more effective in finding important defects quickly as compared to test case based testing. However the experiment only involves test case based testing. We believe there is a need to gather empirical evidences regarding effectiveness of ET in detecting bugs quickly in comparison to other techniques as well.

The results in the industry were very similar to the results at Sogeti. However, testers in the industry reported utilization of tester's creativity as the biggest benefit of ET and utilization of testers experience and knowledge second largest benefit of ET. Therefore based on the information provided by 31 industrial practitioners we can say that appropriate utilization of tester's creativity, experience, knowledge and the ability to adapt well in rapidly changing situations are some of the widely agreed explicit benefits of ET.

2) Disadvantages of Exploratory Testing

Disadvantages of exploratory testing are scarcely discussed in the literature [7]. Therefore this study tries to provide explicit industrial views regarding disadvantages of exploratory testing.
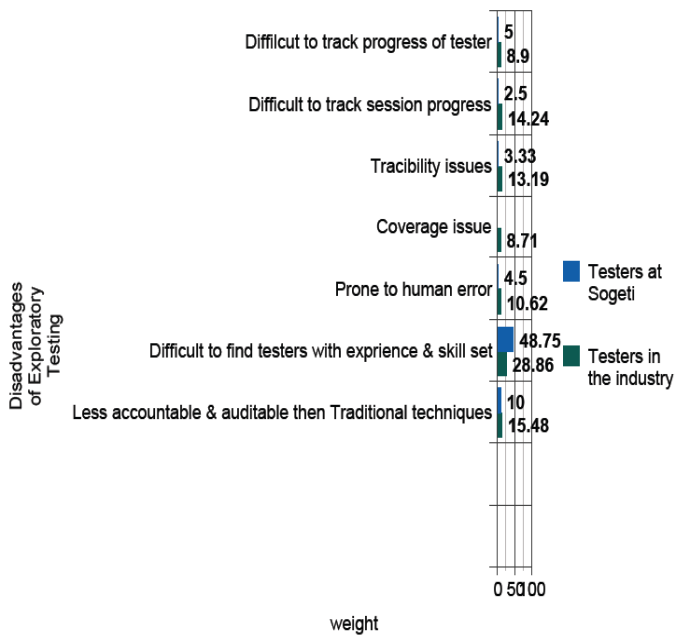

Figure.5: 100$ Test Result for ET Disadvantages by the Testers at Sogeti and Testers in the Industry.

According to the results by Sogeti testers in figure 5, the biggest shortcoming of ET approach is stated to be "difficulty in finding testers with appropriate experiences and skill set. The survey in the industry also gave the similar result. The testers in the industry also stated that it is a challenge to find experienced and skilled tester. Therefore ET results can be of lower credibility if the tester does not have appropriate knowledge and skills required to perform effective exploratory testing. This fact is acknowledged by a number of practitioners in [1][2][7][8][9]. Hence the data collected from

Sogeti and industry testers further asserts this claim. The second biggest disadvantage of ET is that; it is more prone to human error. However, this also happens to be one of the general misconceptions regarding ET (see section IV B). Therefore a conflict raises that whether it is a misconception or a disadvantage. According to our analysis the reason of this conflict is based on the fact that, ET skeptical testers at Sogeti contributed in the 100 $ test and in the information collected for the identification of misconception. All three ET skeptical testers reported ET to be more prone to human errors where as none of them reported this to be a misconception. So based on these analysis; ET being more prone to human error is disadvantage according to the ET skeptical testers and a misconception according to the ET supportive testers. Therefore, there is a need to conduct empirical research to analyze the facts about ET being or not being more prone to human errors in comparison to other techniques.

Another shortcoming of ET is "difficult to track the progress of the test session or the entire testing". According to the results, the data collected from the interviews and analyzed with the literature available we can infer that this is due to the fact that exploratory testing is not a technique it is an approach. A technique is rather easy to handle in a structured manner whereas an approach can be taken with different perspectives and adapted according to need [1][14]. The reason for considering it a disadvantage can also be "mind set" of the customers, as prefer to see numbers and figures as early as possible in the testing activity so that they can perform analysis [14][25].The traceability issue is yet another disadvantage of exploratory testing. The industry practitioners at Sogeti also reported this to be problem. They mentioned that this could be due to the fact that test documentation is not as structured as it is in structured testing. Therefore it is comparatively difficult to trace the bugs or reproduce the bugs with exploratory testing approach. But they also said that this issue is resolvable to a great extent. This can be achieved by making logs of every activity done during the exploratory testing as suggested in SBTM and Sogeti SBET framework. Reporting every issue and defects with the details how they were generated or found. All this information is later used to reproduce bugs or defects. The snapshots of the ET tool in appendix E Part II of the report shows that a very detailed report regarding each mission is submitted. The contents of the ET tool enable the tester to store all the relevant and required information for handling issues of traceability and credible reporting to their customers.

Another disadvantage commonly known is that exploratory testing is less accountable and auditable as compared to structured testing techniques. In our study this disadvantage was only reported by the customers at Sogeti. The auditable issue of exploratory testing can be resolved by credible reporting of the activity and creating logs of every action of a testing session [9][25]. Therefore, Sogeti in this case is a very good example of credible report as their customers are very satisfied with the reports. The accountability issue of ET is related to the reliability issue of ET. This is to know how

reliable testing is and also how reliable the results produced by such an activity are

After presenting the pros and cons of ET from testers perspective, the subsequent sections discusses ET pros and cons from the customer perspective.

3) Data collected by Sogeti Customers

Interviews with 4 of the Sogeti customers were conducted to investigate ET pros and cons from customer perspective. The data collected from the interview resulted in the following general pros and cons summarized in the table 6 below. The table shows the advantages and disadvantage reported by the customers and also their number of occurrences.

TABLE 6 LITS OF THE PROS AND CONS BY THE CUSTOMERS AT SOGETI

	Advantages	Number of occurrences
1	Provides good complementary testing	3
2	Effective in finding missed out bugs	3
3	Focused testing	4
4	Rapid feedback	2
5	Effective when the system is unstable and changing	3
	Disadvantages	
1	Does not provide decision material	4
2	Hard to judge the testing progress	3
3	ET expertise are not available easily	2

Focused testing is reported to be the biggest advantage of ET. The reasons mentioned stated that ET provided the ability to test specific areas extensively and also facilitated the customer to perform selective but extensive testing according to their project requirements and other managerial concerns. Customers also reported that ET was effective when used as a complementary testing specifically in the projects that have a large number of use interactions. Being able to test a large number of user interaction was also mentioned to be one of the reasons for using exploratory testing by the customers. Another benefit of ET realized by the customers is the effectiveness of ET when the system is unstable and changing. This advantage is also mentioned as one of the usages of ET before it had been realized in its current form [4]. The customers also stated that it is useful and effective for testing a project which is in the initial development phase to continuously inspect and validate the development process. The disadvantages of ET reported by the customers are similar to the some of them mentioned by the testers. The reasons for considering them disadvantages also happened to be similar as discussed in section IV part C.2

D. Combination of ET with other testing Techniques

This section presents the lists of techniques in the industry that are considered to be more effective when combined with exploratory testing. The data for this question was collected from the interviews at Sogeti and then from survey in the industry. First it presents the discussion and findings at the case company and then in the industry. The raw data from the interviews and the survey was analyzed to find out the techniques mentioned by the industry practitioners. The motive of this question is to enlist the techniques which are deemed effective and are used in the industry with ET. Study

regarding effectiveness of combinations is not a part of this study. However, we plan to work with this in the future.

1) List of Techniques reported by Sogeti

Exploratory testing is an approach and it can be applied to any testing technique available, apart from few testing techniques such as automated testing [13]. According to James Bach "exploratory testing is profoundly a situational practice"[13] and due to this property; using and combining exploratory testing is dependant on certain factors e.g.

- o Nature of software
- o Complexity
- o Design
- o Customer requirements

The factors mentioned above were reported by the testers at the case company and in the industry as well. Based on these factors exploratory testing can be combined with any testing technique depending on the context which suits the best.

Table 7 shows the list of techniques mentioned by the testers and customers at Sogeti. The list also includes the number of times it was mentioned, to conclude which testing technique is mostly used with ET approach. According to the results, risk based testing is seen to be the most effective combination with ET at Sogeti. The rationale behind could be the fact that when

TABLE 7: LIST OF TECHNIQUES REPORTED BY SOGTIE

	Testing Technique	No of Occurrences
1	Usability Testing	6
2	Risk Based testing	9
3	Requirements based testing	8
4	Pair wise testing	4
5	Cross functional testing	8

you decide to do risk based testing it is easy to decide the test mission and perform testing accordingly. In this condition, testing is more focused in eliminating all the entitled risk of the system. ET was also reported to be effectively combined with requirements based testing and cross functional testing by the customers and testers at Sogeti. However, empirical evidences are required to analyze how effective a combination is and in what context.

When the testers and customers were inquired about different ways of using exploratory testing they mentioned the following:

- o ET in combination with other techniques
- o Complementing other techniques
- o Other techniques were used in an exploratory manner
- o ET solely

In order to get a more generalized and quantitative outcome regarding ways ET was being used we verified the above in the industry through a survey. We also investigated techniques that were used in combination with ET.

2) List of Technique and Usage in Industry

According to the survey in the industry most of the practitioners believe that exploratory testing is a way of thinking about testing, hence can be used with any method of testing. Therefore we investigated the preferred manner to use

ET. The results in figure 6 shows that 43.5% of the testers preferred using exploratory testing in combination with other testing and 25.64 % of the testers preferred to use ET as a complementary testing which also asserts our claim that most usage of ET is seen in combination with other testing techniques. Solely using exploratory testing was supported by only 12.82 %. They reported that testing is not credible if only exploratory testing is used because it is a vale adding technique and should be combined with structural testing for reliable results. Based on this we can infer that ET is preferred to be used in combination with other structural techniques to provide valuable results.
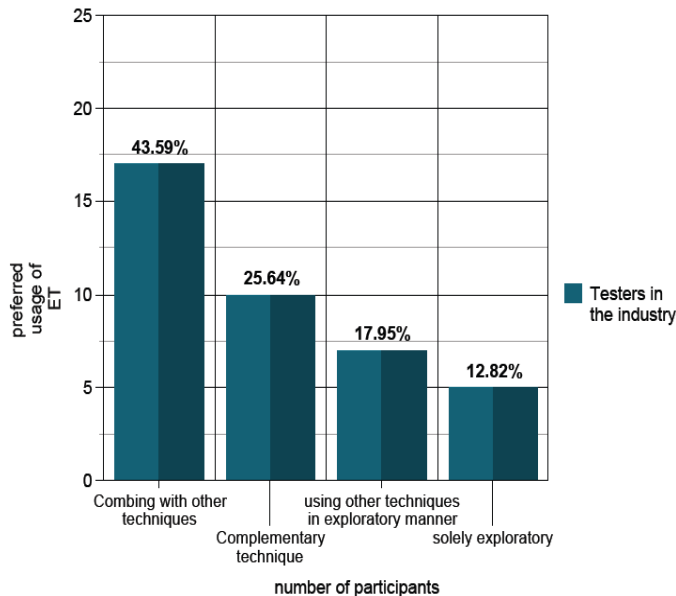

FIGURE 6: Preferred usage of ET Approach in the Industry

Based on the results of the survey, table 8 shows the list of techniques that are reported to be used in combination of exploratory testing by 25 testers in the industry.

TABLE 8: TECHNIQUES USED IN COMBINATION WITH ET IN THE INDUSTRY

	Testing Technique		Testing Technique
1	Usability Testing	6	Scripted Testing
2	Security Testing	7	Checklist based testing
3	Boundary Value (BV)	8	Cross functional testing
4	Pair wise testing	9	Requirements based testing
5	Risk Based testing	10	Acceptance testing

The techniques mentioned in the table above are not the only ones that can be used with exploratory testing. But the motive of listing these techniques was to present the data according to the industry usage and the above mentioned were repeatedly stated by the survey participants. When mapping table 4 and 14 we can see 5 common techniques mentioned by testers and customers in Sogeti and 25 participants in the industry. So we can infer that these techniques are relatively of more importance and applied in combination to ET.

E. Adaptability and Non suitability of ET

The section investigates the area and type of test requirements where exploratory testing is adaptable and where

it is unsuitable. Initially the data was collected from the interviews at Sogeti. Data from the interviews was in descriptive form therefore the data was manually sorted and grouped. The result of the interviews was then used in the survey for further verification by relatively larger sample. The results from survey were quantitative and are presented in graphical form.

1) Area and type of Testing Requirements ET is best Adapted

In the interviews at Sogeti all the testers who considered exploratory testing an approach reported that ET is adaptable in any situation. They further added that the decision should base on rationale of its usage and to the extent it is to be adapted. It is a situational practice and can be customized in relation to the required results [1][24]. The testers at Sogeti also reported that exploratory testing is best adapted in a situation where the prime motive is to perform end user focused testing. They also considered ET the most effective way of bug hunting and adaptive in situation where negative testing is required. The data from the interviews also depicted that, exploratory testing was mostly used when the testing requirement was to perform complementary testing. It is said to be the most effective approach for performing complementary testing. Three other redundantly mentioned test requirements where ET is considered effective are

o learning of the system
o testing under time constraints
o test driven development

The data from the interview was further verified in the industry for generalization of the results. Figure 8 below shows the result from the survey industry. The graph depicts the types of test requirements where exploratory testing is mostly used. 17 of 25 testers that is 68% of the testers in the industry survey reported adapting exploratory testing when the test requirements are

1. Learning of the system
2. testing under time constraints
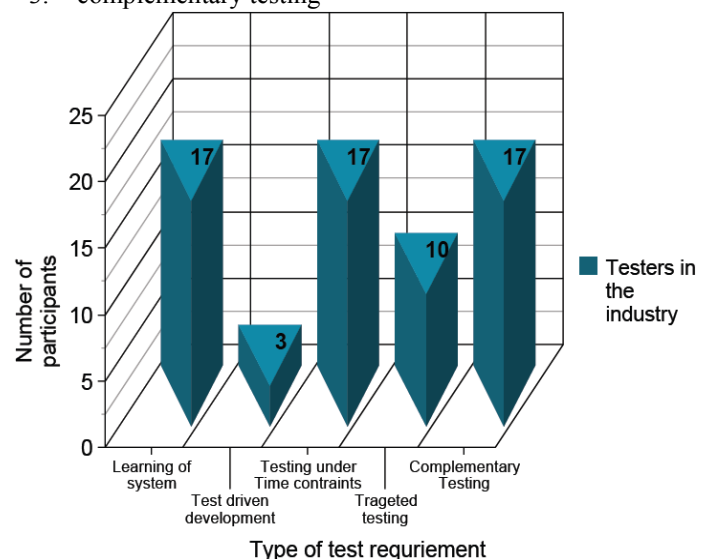3. complementary testing

FIGURE 8: THE TYPE OF TESTING REQUIREMENTS ET CAN BE ADAPTED TO

10 of 25 that is 40 % of the tester in the survey reported adapting ET for targeted testing and only 3 of 25 that is 12% opt test driven development. The testers in the industry also mentioned that ET is best adapted to areas of the product or project which requires end user focused testing. Therefore, based on the results from Sogeti and industry we can infer that exploratory testing as compared to structured testing is significantly more effective in handling user interaction. It is effective where structured testing is limited. For example it is impossible for a tester to design test cases for all the possible user interactions of the product. On the other hand exploratory testing in this case can be very useful to explore, design and execute test cases for user interactions simultaneously. Here ET would be more efficient and effective in finding bugs. Therefore, Software made for a broad audience of users, i.e. software that is intended to be used by a large numbers of users with various skills and experience in using computers, software and/or services. Some good examples of types of software/services that could benefit from the ET approach can be facebook, LinkedIn, Twitter, Wordpress and Joomla etc.

Exploratory testing can be effectively adapted to test the area of the product with little understanding that is learning of the product. It is also adaptable for testing of system where the system solution is not known from start for example game systems and in agile projects.

Following is the list of test requirements or situations where exploratory testing can be adapted drawn from the interviews with the case company and the industry

- o when there is little time available for testing
- o when other test efforts don't yield any important information
- o when you don't know much about the product under test
- o when the product is very complex
- o when the testers have a lot of knowledge and experience of the product and of testing
- o when docs and /or requirements are vague or are deficient
- o functional and non functional testing
- o when system is unstable and changing continuously

Apart from the above according to our understanding, legacy systems are good candidates of exploratory testing as they are to be learned and transformed into new tools and technologies.

2) Area and type of Testing Requirements ET is not suitable for

Exploratory testing approach is deemed unsuitable for some types of systems and testing requirements. The descriptive data collected from the interviews and the survey in the industry was studied to list the types of the system and test requirements where exploratory testing is unsuitable.

Therefore following is the list of system types where exploratory testing is not suitable.

- o High risk systems e.g. aviation system
- o Critical systems e.g. medial systems

- o Financial systems e.g. banking systems
- o Scientific systems e.g. nuclear reactor systems

All the above mentioned systems require as accurate testing as possible. There is no room for mistakes or leaving out areas without testing. Therefore these systems are tested rigorously in a structured manner and exhaustive documentation is very important. But still exploratory testing can be used for these systems as well to meticulously test the system at any given point.

We also inquired the test requirements where exploratory testing was not a suitable choice. The following list shows the test requirements where ET is not suitable

- o Test requirements related regression testing
- o Beta/acceptance testing
- o Structural testing
- o Unit testing and performance testing

Apart from the above mentioned list most of the testers in the industry also reported that it is not suitable to do the entire testing process using exploratory testing only. The reasons mentioned were that with exploratory testing it is easy to make mistake and forget test cases so it should not be the only test technique used. They also mentioned that structured test techniques are more traceable, reliable and can cover the system under test in more sophisticated way there for solely exploratory testing would not be a suitable choice.

V. VALIDITY EVALUATION

The threats to the proposed study were argued according to the validity evaluation presented by Clase Wohlin in [20]. One particular type of validity threat that is construct validity discussed in [20] is unrelated to our investigation. This type of validity is concerned with the mapping from real world to the laboratory. The study presented here is how ever a real world study but performed in the industrial environment. Validity threats that were considered for this investigation are the following:

1. Internal Validity

A digital recorder was used during the interviews for later referencing. This could be considered as a setback due to the fact that most of the people get confused and conscious knowing that they are being taped. They might feel constrained answering on behalf of their organization and the information delivered might be suppressed. This problem was tried to be eliminated by assuring anonymity of the information and the usage was restricted solely for research purposes.

2. External Validity

Generalization of the result is main concern of the external validity. This might be a validity threat in our study as results from a single organization cannot be generalized for all the other similar organizations. However the case organization is one of the most established and large organizations in their respective sectors, hence the data collected from them can be considered authentic for research purposes. The result from the survey taken by a larger number of testers also helps in generalizing our findings and balances the threat to some extent. The selection of participants can also be a threat in this

study as they might not be the most suitable for the purpose. However the selection of the participants was meticulously performed according to the requirements of the study in order to minimize this threat.

3. Conclusion Validity

The investigation instrument that is the questionnaires used for the semi structured interviews was validated through proofreading by the advisor and few independent external means not involved in the study. This was done to avoid the risks of poor question wording and erroneous formulation. Each case study interview was conducted without any coffee or tea break hence the answers were not influenced by any sort of discussions about the questions. Results of the study can also be a conclusion validity threat. So to ensure the validity the results were communicated with the case company and a number of participants in order to minimize this threat.

4. Data Triangulation

Data triangulation was performed by collecting data from multiple sources. The sources were ten people from the case organizations and multiple documents from the organization. Some of the qualitative data collected was also validated by the quantitative data collected from the interviews. The triangulation of result was also performed to extent by verifying the results from the case company through a survey in the industry.

5. Ethical Considerations

Ethical values were seriously considered before, during and after the investigation. The data collected from Sogeti was not interchanged or revealed to any other company. The identity of the company was revealed by its consent however the company wanted its customers to be anonymous. We also pledge not to disclose any details of the companies' document that were examined for our study. Data collected by Sogeti customers was only used for research purposes. All the personal inferences that were drawn from our discussions with the company personals were not represented as the company's point of view.

VI. SUMMARY OF RESULTS

This section briefly summarizes the results of our investigation with some suggestions for the future work. It also states our contribution to the current state of knowledge in few words.

After performing the literature survey of the material related to exploratory testing we believe that this topic requires a lot of research in all aspects [7][26]. It requires empirical evidences to verify the claims made related to its effectiveness, efficiency, benefits, shortcoming and adaptability. Based on our finding in this investigation some of the important purposes of using exploratory testing from the tester's perspective are learning of the system and the ability to effectively utilize tester's time and abilities. On the other hand from the customer's perspective the important purposes of using ET are targeted testing and time constrained testing where extensive testing in not a requirement. According to the study the testers do not use exploratory

testing because the customers are not satisfied by the approach and the results are not considered credible. Based on our research we can say that this is due to lack of knowledge regarding the approach or the type of the system is not suitable for testing with exploratory testing. Our study contributes by highlighting the purpose using and not using exploratory testing from the customer and testers perspectives.

One of the main contributions of our study is the Sogeti SBET framework. This framework exemplifies a practical implementation of exploratory testing in the real life industrial setting. This framework however can be customized by any other organization that intends to perform session base exploratory testing. We initially plan to validate the framework in Sogeti and the in industry in our future work. Our study investigated the misconceptions related to ET as well and based on study; biggest misconception related to ET is that it is considered a technique rather than an approach. Therefore there are a lot of doubts regarding its usage and reliability of results. From the testers perspective the biggest misconception is that, the customers are not satisfied with the results of ET. Whereas most of the testers in the study negated this opinion regarding ET and the results of the survey further assert this to be a misconception. The customer opinion regarding this misconception also depicts that they are satisfied with ET but there is a need to improve the reporting of the session in order to produce reliable comprehensive decision material. One of the biggest misconceptions of exploratory testing from the customer's perspective is that it does not provide complete coverage of the system. According to the testers in the study it is possible to completely cover the system testing however due to little or no reliance on structured documentation and simultaneous design and exertion of test cases it is easy to forget the test case or commit mistakes. But this is similar case with structured testing as well. Despite of being very well structured there is always a chance to commit mistake or skip an area for testing. Therefore this issue requires empirical research to investigate whether exploratory testing is capable of providing complete coverage or not. The study also showed that the customers found it difficult to track progress of the testing process or the testers. However after this study we can infer that session based testing can resolve issues related to the progress of the testing process or the testers. Misconception of ET from the customer perspective have never been discussed prior to this study, therefore this is also one of our contribution to the current state of knowledge.

In this study we investigated some of the claimed and perceived pros and cons of exploratory testing in the industry in order to deduce explicit pros and cons of ET. Based on the study the biggest benefit of ET from testers perspective is utilization of tester's experience and knowledge which asserts the claim made by industry practitioners in literature [1][14]. One of the aspects not reported prior to this study is that the testers feel pride in their work and ET brings more fun, freedom and responsibility to their work as compared to structured testing. One of the biggest disadvantages of

exploratory testing from the tester's perspective is the inability to find testers with appropriate experience and skill set. Customers find it challenging to find good exploratory testers. During the investigation ET being more prone to human error was stated as misconception from the testers and also as a disadvantage of exploratory testing therefore study distinguishing the misconceptions and the disadvantage would aid in perceiving the concept more precisely. According to the customer perspective the biggest benefit of ET is the ability of providing focused testing. ET facilitates the customers to perform selective but intensive testing according to the project requirements. One of the suggested future works in his respect is to further verify the pros and cons by gathering extensive empirical evidences or conducting experiments. Our contribution here is a list of explicit pros and cons of exploratory testing with respect to tester and customer perspectives.

Based on the information congregated in this study we can say that exploratory testing is widely used in combination with other testing techniques in the industry. Being an approach it can be used with any other testing technique but it is mostly reported to be used as a complementary testing approach in the industry. Some of the testing techniques that are used in the combination with ET in the industry are risk based testing, scripted testing and cross functional testing to name a few.

According to the literature [9][13] exploratory testing is a situational practice therefore its effective use should be based on the rationale of its usage. According to the study, the test requirements where ET is adaptive are learning of the system, testing under time constraints and complementary testing. Based on our study we conclude that exploratory testing is very effective in testing a system that has a larger number of user interactions. Whereas, it is very difficult to design test case for every user interaction in structured testing. Exploratory testing is not suitable choice for testing critical system and neither is preferred in the industry. However exploratory testing is used for high risk systems but as a complementary approach. Another mutual consensus seen among the tester in study is that solely using ET for the entire testing process is not suitable as structured testing techniques are traceable, reliable and can cover the system under test in a more sophisticated manner.

VII. CONCLUSION

To conclude the study we can say that although ET concept has gained better understanding over the period of time but still requires a lot of research and study of industrial practices to utilize the approach in a better manner. The study also concludes that there is a lack of research on the use and effect of applying exploratory testing and a number of related claims need verification. Exploratory testing is mostly used for targeted testing and as a complementary approach therefore it is a value adding approach that is very effective when used with structured testing. However session based testing approach has provided due structure to this approach that

enables ET to be managed, controlled and tracked structurally. The customers in the industry are starting to realize its effectiveness but want ET to produce detailed decision material that enables them to take decisions based on the reports. They also require ET process to be more visible in terms of progress of testers and the entire testing process. The adaptability and suitability of ET depends on the situation and the complexity of the system under test. So to conclude; exploratory testing is a value-added testing approach that enriches the test procedure.

REFERENCES

[1] Tinkham, A., & Kaner, C. "Exploring Exploratory Testing". Paper presented at the STAR East 2003 Conference, Orlando, FL, USA. Visited 2009 09 21http://www.testingeducation.org/articles/exploring_exploratory_testing_star_east_2003_paper.pdf

[2] Bach, J., "Exploratory Testing", chapter in The Testing Practitioner, Second ed., E. van Veenendaal Ed., Den Bosch: UTN Publishers, 2004, pp. 253-265.

[3] C. Kaner, J. Bach and B. Pettichord," Lessons Learned in Software Testing" , New York: John Wiley & Sons, Inc., 2002.

[4] C. Kaner, J. Falk and H.Q. Nguyen, "Testing Computer Software", New York: John Wiley & Sons, Inc., 1999

[5] Creswell J, "Research Design: Qualitative, Quantitative and Mixed Method Approaches". Sage Publications Ltd, 2002.

[6] IEEE, "Guide to the Software Engineering Body of Knowledge", IEEE, Tech. Rep. IEEE - 2004 Version, 2004

[7] Itkonen, J. and K. Rautiainen. "Exploratory Testing: A Multiple Case Study", in Proceedings of the International Symposium on Empirical Software Engineering (ISESE 2005), pp. 84-93, 2005

[8] Itkonen, J., M. V. Mäntylä and C. Lassenius. "Defect Detection Efficiency: Test Case Based vs. Exploratory Testing", in proceedings of the International Symposium on Empirical Software Engineering and Measurement, pp. 61-70, 2007.

[9] J. Bach. "Session-Based Test Management", STQE, vol.2, no. 6, 2000.

[10] L. Copeland, "A Practitioner's Guide to Software Test Design", Boston: Artech House Publishers, 2004.

[11] R.D. Craig and S.P. Jaskiel, Systematic Software Testing, Boston: Artech House Publishers, 2002.

[12] R.K. Yin, Case Study Research: Design and Methods, London: SAGE Publications, 1994

[13] Bach J., "Exploratory Testing Explained", Published as a chapter in The Test Practitioner, 2002. Visited 2009 08 20, http://www.satisfice.com/articles/et-article.pdf

[14] Cem Kaner & James Bach, "The nature of exploratory testing." Lecture at Tampere, Finland, May 7, 2004.

[15] Lyndsay, J. "A positive view of negative testing", Workroom Productions Ltd. March 19, 2003. http://www.workroom-productions.com/papers/PVoNT_paper.pdf.

[16] Lyndsay, J. and N. van Eeden. "Adventures in session-based testing". Workroom Productions Ltd. May 27, 2003. http://www.workroom-productions.com/papers/AiSBTv1.2.pdf.

[17] Tinkham, A and Kaner. C,"Learning styles and exploratory testing". Pacific Northwest Software Quality Conference, 2003.

[18] Kaner, C. "A Course in Black Box Software Testing", 2002, Summer (Professional Version), 2003, from

http://www.testingeducation.org/coursenotes/kaner_cem/cm_200204_blackboxtesting/

[19] Hazzan, Orit & Dubinsky, Yael . "Agile Software Engineering". Undergraduate Topics in Computer Science, Springer, 2008

[20] C. Wohlin, P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell and A. Wesslén, "Experimental Software Engineering -- An Introduction", Kluwer Academic Publishers, ISBN 0-7923-8682-5, 2000.

[21] Mark, Scott. "Test-Driven Development: An Agile Practice to Ensure Quality is built from the Beginning". Ioannis G.Stamelos & Panagiotis Sfetsos: Agile Software Quality Assurance, 2007. Information Science Reference.

[22] Pettichord, Bret 2002. Agile Testing – What is It? Can it Work?, Online, Visited 2009.09.30 http://www.io.com/~wazmo/papers/agile_testing_20021015.pdf

[23] Myers, G. J. "The Art of Software Testing", John Wiley & Sons, New York, 1979.

[24] Kalman, Sam, "Session-Based Test Lite." Quardev Laboratories. May, 2007, Visited 2009 10 05 http://www.quardev.com/content/whitepapers/SBTMLite_samkalman.pdf

[25] James, Jonathan Bach "Exploratory Testing Dynamics" Visited, 2010 01 02 http://www.satisfice.com/articles/et-dynamics.pdf

[26] Itkonen, J. "Do test cases really matter? An experiment comparing test case based and exploratory testing". Licentiate Thesis. Helsinki University of Technology, 2008

APPENDIX A: RESEARCH QUESTIONS, AIMS AND OBJECTIVES OF THE STUYD

This appendix describes the aims and objectives of the thesis. The research questions designed to achieve the aims are also mentioned and discussed in the appendix.

A.1   Aims and Objectives

This thesis aims to investigate the misconceptions related to ET. While doing so, we shall collect evidence regarding its practice, pros and cons from its stake holder's perspective, in a real-time industrial test settings. Following are few objectives that we have tried to fulfill in order to achieve the aims of the research.

- Exploring ET from the perspective of academia and the way it is practiced in the industrial test settings.
- Study a practical example of ET.
- Investigate the misconceptions related to ET and the rationale behind them.
- Study ET from the standpoint of its stakeholders and also find out the pros and cons according to them.
- To discover the circumstances where ET is a suitable and where it is not a suitable choice.

A.2   Research Questions

The research questions for the thesis were designed keeping in mind the above mentioned aims and objectives. These questions were designed and finalized in collaboration with the case company and the research advisor. The case company's requirements and expectations from the research was the major influence in designing the research questions as it had proposed the research. Each research question below is followed by their rationale. The expected outcomes of the study which were discussed prior to the start of the research with the case company and advisor are listed at the end.

Research Question 1: What is exploratory testing (ET)?
Rationale
This research question intends to describe, explore and define exploratory testing in detail. ET is studied from the perspective of academic circles and also the way it is practiced in the industry. In depth study of the process of performing and managing ET is conducted. The answer to this research question is extracted from the literature study of all the related, relevant and available resources according to the best of our knowledge.

Research Question 2: How ET is being practiced in real time industrial setting?
Rationale
In this research question we have focused on how ET testing is being practiced in an industrial setting. We have studied in detail how the ET activity is being managed and carried out. This is show a practical example of ET being carried out in the industry successfully. For conducting this study we have performed interviews, on site observation and document analysis at Sogeti.

Research Question 3: What misconceptions are related to exploratory testing?
    a.   From the testers/technical stand point?

b. From the customers stand point?

Rationale

This research question explores the misconception related to ET in depth. The research question is divided into two parts. Part "a" intends to focus and explore the misconceptions regarding ET from the testers or technical viewpoint. Whereas the focal point of part "b" of the research question is to study the misconception of the customers or product managers. In this research question we have also tried to explore if the concept of ET testing; like many others, is also a victim of human nature, as it finds it difficult to adapt new things and changes. The answers to this question are extracted from the relevant literature review but mostly from the interviews conducted at Sogeti. We yearn to conduct interviews with people working with ET and people not working with ET. This would include testers using ET and Testers not using ET and also customers who are using ET and not using ET.

Research Question 4: What are the advantages and disadvantages of exploratory testing?

a. From the testers stand point?

b. From the customers stand point?

Rationale

This research question intends to investigate the pros and cons of exploratory testing ET from the testers and customers stand point. It would help understand the concept of ET in more detail. The ET as it is practiced in Sogeti would be the focal point here but have also gathered data from a relatively larger sample of testers in the industry to compare and generalize our findings.

Research Question 5: Which other testing methods ET can effectively combined with?

Rationale

This research question aims to find out the list of other techniques in the industry which are considered to be more effective when combined with ET.

Research Question 6: For which areas and test requirements ET

a. Is best adaptable? Why?

b. Is not suitable? Why?

Rationale

In the first part of this research question we have focused on the areas of product or project, test environment, test requirements and test types ET can be best adapted. The second part of the research question focuses on the area where ET is not strong as compared to other testing techniques or methods. The answer for this research question is extracted from the interviews and the survey in the industry which gives us the insight about where ET is considered suitable and unsuitable in the industry.

A.3   Expected Outcomes

The output of this research would be a detailed report consisting of the following very briefly listed outcomes. These outcomes are in accordance to the research questions to fulfill the aims and objectives of the thesis.

1. A detailed analysis of what ET is according to the literature and industrial practitioners. A comprehensive definition of ET.
2. A procedure or approach that is being practiced in the industry.
3. A list of most common misconceptions related to ET and the rational behind them.

4. A table showing the pros and cons of ET from the technical/testers and customers standpoint.
5. A table/list showing the areas and types of testing ET is suitable and unsuitable for.
6. A list of methods ET can be effectively combined with and their analysis.

In the report preceding each outcome is a detailed discussion on how these outcomes where attained.

APPENDIX B: LITERATURE SURVEY

In this section, a literature review of existing research and related work is presented. The concepts discussed briefly in the paper are detailed in this appendix. The objective of this literature study is to review the existing empirical evidences regarding exploratory testing.

This appendix is divided into two parts. B.1 details the methodology used for conducting the literature review. B.2 comprises the literature study of exploratory testing approach and other related concepts that are used and referred in this research.

B.1   Survey Methodology

A literature review on previous research and existing knowledge regarding exploratory testing (ET) was conducted. The objective of conducting the survey was to explore exploratory testing from academic perspective and the way it is practiced in the industry. The survey was later used as a knowledge base to understand, explore and define the concept of exploratory testing.

To conduct the literature review, no formal methods such as systematic reviews were used. The motive for not using any formal method was primarily due to the fact that there is no established scientific research available for exploratory testing. That means we were unable to find review material form the academic databases using relevant keywords. Other than that the search mostly returned irrelevant papers and material when more generic terms were used. Most of the relevant material found was from practitioners books, lectures delivered in different conferences by the guru's of exploratory testing and different internet resources. Hence following were the primary search engines and sources used for extracting review material.

- IEEE Explorer database
- Google scholar
- ACM Digital Library
- Literature available at practitioners websites such as Cem Kaner (www.kaner.com) James Bach (www.satisfice.com) and Itkonen Juha (www.soberit.hut.fi/jitkonen)
- All the publication related to exploratory testing

We also tried to review all of the relevant references of the related publications found. Significant sections of a number of software testing text books were reviewed for comprehensive understanding of the concept.

B.2   Exploratory Testing

Exploratory testing is a relatively new concept of software testing that has gained attention of industry practitioners recently. Industry practitioners are making efforts to promote the learning, understanding and implementation of the concept. These days ET is getting a lot of attention in books, conferences and software testing education. The concept of exploratory testing has been acknowledged in software testing books since 1970 [2]. This approach has been exercised by the testers knowingly or unknowingly. But still it faces difficulties in being realized as an approach for performing effective software testing [2] [3]. Exploratory testing is also known as ad hoc testing by industry practitioners mainly

due to it being less structured as compared to traditional testing techniques specifically scripted testing [13]. This approach is discussed in details in the following sections.

B.2.1 Development of Exploratory Testing Definition

The definition of exploratory testing has developed over time. Specifically after the attention it has gained in recent years. The practitioners have also improved their understanding and practices of this approach. Therefore, in this section we would discuss the development of different definitions of exploratory testing over time.

Although this approach in its current state has gained focus recently but was recognized since 1970's.Glenford Myers in his work realized exploratory nature of testing when working with error guessing technique [23]. It was usually considered to be ad hoc testing and error guessing technique. Therefore, in 1988 Cem Kaner in the 1st edition of their book "Testing Computer Software" thought up and realized the terminology of exploratory testing [4][13] and disagreed with it being an ad hoc or careless work . Rather they considered it to be an intellectual activity which provides more control to the testers. At that time, they described its usage as a testing process which was carried out after the scripted tests were conducted. Specifically when the project was in an unstable state and could undergo changes. They used this approach to continue testing but without investing a lot of effort in designing and executing scripted tests, keeping in mind the changing state of the project [4][7]. Later in 1999, exploratory testing was described as simultaneous learning of the system in parallel with designing systematic scripted test scenarios [4].

Definitions of exploratory testing have been offered by a number of industry practitioners. According to James Bach [2] exploratory testing is "*simultaneous learning, test design and test execution"*. Cem Kaner and Tinkham refer to it as "*Any testing to the extent that the tester actively controls the design of the tests as those tests are performed and uses information gained while testing to design new and better tests*" [1]. Kaner, Bach and Pettichord also take exploratory testing as a purposeful wondering without scripted notes for a mission. Whereas exploration involves, simultaneous learning and testing of the system under test. According SWEBOK [6] "*Exploratory testing is defined as simultaneous learning, test design, and test execution; that is, the tests are not defined in advance in an established test plan, but are dynamically designed, executed, and modified.*" But it also emphasizes the fact that the effectiveness of this activity relies on knowledge of the software testers. Whereas, the knowledge can be derived from several related sources e.g. associated risk Lyndsay and van Eden [16] have a view that exploratory testing is the way experienced testers perform testing. Lyndsay's work related to negative testing provides another insight to exploratory nature of testing. Negative testing means "*tests designed to make the system fail, and tests that are designed to exercise functionality that deals with failure*" [15]. The introduction of the new concept of secondary negative testing strengths the fact the exploratory nature of testing can be used widely and effectively. In secondary negative testing new test cases are created based on the risks, faults and weaknesses found in previous tests. This clearly depicts that this type of software testing facilitates the process of finding new risks and identifying weakness in new areas of the system [7].

We can clearly see the development and improvement in understanding of exploratory testing i.e. from ad hoc error guessing technique to a thoughtful approach to fulfill a test mission. James Bach in 2009 provided a new definition of exploratory testing. According to him "*Exploratory testing is an approach to software testing that emphasizes the freedom and responsibility of each tester to continually optimize the value of his work by treating*

learning, test design and test execution as mutually supportive activities that run in parallel throughout the project".

B.2.2 What is Exploratory Testing

After studying a lot of definitions (see section A.2.1) of exploratory testing we can say that it is an approach which provides more value to the work of testers. As they are allowed to use their, knowledge, intellectual abilities, experience and testing skills to solve the problem at hand. This freedom increases their sense of achievement after accomplishing their tasks. According to Kaner and Bach [14] exploratory testing is simultaneous learning about the product, the market, the weakness of the product, the ways the product to could fail. This approach in contrast to traditional approaches and techniques of software testing does not follow the conventional coverage-driven test case design paradigm [7][14]. It does not rely on pre test documentation and test case designing as well. Based on this a Finish study [7] derived five characterizing properties of exploratory testing which are as following.

1. Tests are not defined in advance as detailed test scripts or test cases. Instead, exploratory testing is exploration with a general mission without specific step-by-step instructions on how to accomplish the mission.

2. Exploratory testing is guided by the results of previously performed tests and the gained knowledge from them. An exploratory tester uses any available information of the target of testing, for example a requirements document, a user's manual, or even a marketing brochure.

3. The focus in exploratory testing is on finding defects by exploration, instead of systematically producing a comprehensive set of test cases for later use.

4. Exploratory testing is simultaneous learning of the system under test, test design, and test execution.

5. The effectiveness of the testing relies on the tester's knowledge, skills, and experience.

These characteristic can be helpful to realize in what ways and to what degree testing is exploratory testing. In 1999 authors[1] at the 7th Los Altos Workshop on Software Testing (LAWST VII) highlighted some of the common characteristics according to their views. The concluded characteristics of exploratory testing were:
  • Interactive
  • Concurrence of cognition and execution
  • Creativity
  • Drive towards fast results
  • De-emphasize archived testing materials

B.2.2.1 Advantages and Disadvantages of Exploratory Testing

According to our knowledge based in the literature review, most of the conversed advantages of exploratory testing are based on its comparison with test case based testing

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[1] Brian Lawrence, III, Cem Kaner, Noel Nyman, Elisabeth Hendrickson, Drew Pritzger, Dave Gelperin, Harry Robinson, Jeff Payne, Rodney Wilson, Doug Hoffman, James Bach, James Tierney, Melora Svoboda, Bob Johnson, Chris Agruss, Jim Bampos, Jack Falk, Hung Q. Nguyen and Bret Pettichord

or scripted testing approach. We deem there is a need to study exploratory testing approach in terms of advantages, in comparison to other testing techniques and approaches which are not based on scripted testing [8]. According to our literature survey we have managed to encompass following advantages of exploratory testing which are also discussed in various resources [1][2] [3][4][7][13].

- **Testers utilization**
  The most agreed upon advantage of exploratory testing is the utilization of tester's knowledge, skill, abilities and experience. It provides more power to the testers, which in result are capable of making valuable contributions to testing process.
- **Provides simultaneous learning**
  Exploratory testing approach provides simultaneous learning of the system under test. This learning can be about the product, the market, its weakness and how the system can fail. The learning of this system is also important for creating test cases. The testers learn from their experience and develop new tests based on what they learned.
- **No or little test preparation**
  Another important advantage of exploratory testing is that it does not require extensive amount of pre test planning and documentation. This saves a lot of time and effort of the testers which they can utilize during the testing activity. Exploratory testing approach believes in discovering the bugs or defects by exploration rather than following detailed test specification or scripts. It can specially be very useful when the risk of changes in project under test is high.
- **Effective**
  This approach is considered to be more effective in finding the number of significant defects as compared to scripted testing. This has been supported by anecdotes provided by James Bach [13] and a case study "Defect Detection Efficiency: Test Case Based vs. Exploratory Testing" described in [8]. The case study also provides evidence that exploratory testing produces less false defects as compared to test case based testing. On other hand exploratory testing was found extremely useful in revealing the defects which were difficult to detect.
- **Efficient**
  Exploratory testing approach is more efficient in applying different testing theories in different situation according to the project requirements. It is also said to be efficient as it reveals defects that are more difficult to find and significant. It provides efficient testing in complex situation, when little is known about the product or the system to be tested.
- **Rapid feedback**
  Rapid feedback is another benefit of exploratory testing approach. The developers and testers are able to converse the status and progress of the product under test. Due to rapid feedback, the product can undergo rapid reforms.
- **Adapts well to changing project situation**
  This advantage of exploratory testing is long known, even prior to the time when this activity was realized as in its current form. This approach adapts very well to the rapidly changing requirements of the product as it does not require preparation documentation prior to the start of testing.

With all these advantages, this approach has some disadvantages as well. During our literature review we realized that a number of misconceptions related to this approach such as being ad hoc are considered to be its disadvantage. In this section we would be discussing the identified setbacks of exploratory testing approach but there is not much said about it in the exiting literature. We could only find a Finish study [7] that discusses their

findings regarding the disadvantages of this approach. Too much reliance on knowledge and ability of the tester is seen to be a disadvantage of this approach. It is believed that due to this the testing activity is more prone to human errors than systematic testing. Here rises the question that even systematic testing is prone to human errors. Test cases or test scripts are designed by human and there are equal chances of committing mistakes. The test case designer might miss out some functionality of the system and despite the system being systematically tested; those specific portions of the system would never under go testing. Where as, with exploratory testing approach it is more likely that you would find such parts of the system during your exploration. Another disadvantage of this approach is the coverage issue. It is said that it is difficult to track the progress of the product and to know how much testing has been done [1] [7]. The coverage issues are also related to the planning and selection of what needs to be tested with exploratory testing. The study [7] shows that it is difficult to prioritize what needs to be tested, especially when you have time constraints. In this case, you have to look for expert testers in that domain to produce adequate testing. Reproduction of defects is also seen as a disadvantage of this approach. In exploratory testing it is hard to reproduce the bug again in order to report it. This process some times takes a lot of time. But appropriate test session logging can solve this problem to some extent.

B.2.3   Exploratory Testing Types

There are no explicit types of exploratory testing specified in the literature. But there are few styles which are particularly being practiced in the industry and are discussed by the practitioners. Exploratory testing approach is intensely situational [1] and any testing technique can be used in an exploratory manner may it be test case based testing. How ever to maximize the productivity and to have more control over the testing process, exploratory approach is exercised in the following styles.

B.2.3.1   Free Style Exploratory Testing

Free style exploratory testing is a focused wandering of the system under test without following any test plans or specification. The utmost purpose is to find the bugs and report them at the end of testing. Not following predefined test procedures does not mean unmanaged testing. Regarding this, Bach talks about few guidelines for managing exploratory testing [13] which are as following.

Free style exploratory testing can be executed by assigning charters to the testing team. The charters are allocated by the test lead. The testers are then responsible to accomplish their charters. They design, execute and repot their charters. This approach of free style exploratory testing is called managing by delegation [13]. It tries to apply individual test management on the testers. By doing this testing process becomes auditable. To further make this process more controllable; frequent meetings can be conducted to discuss the progress of testers and problems they experience [1]. Test reporting in this style can be verbal or written. Managing exploratory testing by delegation helps in assessing the individual performances of the testers. It also helps in understanding the capabilities and expertise's of the testers involved which can aid in assigning further tasks.

Another way of managing free style exploratory testing is managing by participation [13]. The test lead participates in the testing activity like other team members. The approach boosts up the efficiency of entire team members, as the lead is continuously directing the test strategies and conveying his expectations from the team members. The active participation of the leader helps in prompt decision making during testing. His experience tends to relegate the potential of uncertainty and inefficiency of testing using an exploratory approach.

Free style exploratory testing term creates a misconception of being unmanaged and merely playing with the system under test. Where as free style exploratory testing utilizes the strengths of this approach the most [1],[13]. In this style the testers are likely to use the intellectual powers without any disruption engendered by managing or mechanizing the testing activity. Which enable the testers to design right tests and at the right time. This would facilitate in finding imperative problems promptly.

B.2.3.2 Using Session Based Test Management (SBTM)

Session based testing (SBT) is interchangeably used with session based test management (SBTM). This approach has recently been introduced to provide more structure to exploratory testing or to unscripted testing in general. In this approach a session represents a single work unit. Each session has a mission or charter to accomplish. To fulfill the charter an uninterrupted time constrained session is held by the testing team. The suggested time frame for SBT is 90 minutes but it is not a compulsion, as stern time limitation can affect quality of testing [9]. This time frame comprises testing only. It excludes the tasks related to testing process such as, set up time or bug reporting. By maintaining an account of these sessions and the missions accomplished by them we can keep track of what is being done and achieved. This method provides the ability to predict the number of sessions required to fully test the system .By doing this the progress of the entire testing cycle can be predicted and an approximation of how long testing would take can be made. The tasks in a session are broken down into sub tasks. The sub tasks are further divided into three types which are referred as task breakdown metrics

- Setting up a session
- Test design and execution
- Bug identification and reporting.

Each session is concluded by debriefing which is a must of SBT approach. The session is reported, discussed and accepted in the debriefing meeting. The testers in SBT approach are asked to fill out a session sheet. This sheet contains all the information about the session and is stored as report for the session. The session sheet mainly consists reporting of bugs, issues and notes [9].

- Bug : are the defects and quality concerns discovered
- Issues: are problems related to the session or the product under test
- Notes: are suggestions, findings, risks anything that takes place and is important to communicate.

This sheet is further used for creating data for the management and to analyze the progress of the testing process.

Exploratory nature of testing intends to find bugs other than what is being searched. The tester can easily divert form its charter or mission. But on the other hand the revealed bug cannot be over looked. To solve this problem Jonathan Bach [9] suggests having another metric of *on charter vs. on opportunity*. This metric reflects the time spent on what was in charter and the time spent on other issues which were not apart of the charter but significant and required attention. Following is the structure of a final session report.

- The mission of the session
- Date
- Starting and ending time
- Name of the tester
- Task break down metrics

Another approach regarding the SBT is proposed by Sam Kalman [24] referred as SBT Light. The need to propose this approach is based on the drawbacks of the original SBTM approach. The drawbacks are said to be

- Extra training; as a good session highly depends on knowledge and practice of the testers.
- Additional reporting is an over head for the testers which can affect their performance. More testing time is likely to be spent on session reporting.
- Analysis of the reports consume a lot of time as the reports are to be discussed and finalized by everyone involved in the session. Hence less time is spent doing testing.

Keeping in mind these disadvantages the [24] proposes to have two different components, project components and reporting components. Each component outlines the benefits and cost related to it. These components can be selected and adapted according to the needs of the session. By doing so author intends to maximize the benefits and minimize the cost of the project. Details about this concept can be found in [24].

Lyndsay and Van Eden [15] reported a case where they used their own session based testing approach. In this approach they used the notion of "test points". Test points were used to manage the scope and the coverage aspects of testing. The concept of test points is described as a single unit of work and a session is said to be a unit of time. The testing task is divided into test points and these test points are accomplished in the sessions. The progress of testing is controlled by calculating the test points covered in a unit of time. The data collected for each test is as following [15]:

- Description
- Risk
- Time spent
- Estimated completion time
- Estimated percentage of the essential testing concluded

Hence this approach differs from the previously discussed approaches of SBT. The authors also reported their experiences when applied this approach in case organization. The ability to measure and control exploratory testing process was said to be increased. Also the testing progress was more visible to the test managers.

B.2.4   Exploratory Testers

Testers are the most significant element of exploratory testing approach. They are the most important factor for conducting good quality exploratory testing. As mentioned in various literatures (see section A.2.1) effectiveness, efficiency and success of this activity relies on the knowledge, skill and experience of a software tester. According to James Bach [13], the inner structure of exploratory testing approach lies in the mind of the testers. A software tester who has superior exploration abilities would excel in performing good exploratory testing. He also identifies few basic skills an exploratory tester should have or try to have [13]. These skills can be stated as characteristic of an exploratory tester. An exploratory tester should be

- A good test designer: who can efficiently and skillfully design tests and think critically.

- A careful observant: who has excellent observation and can identify unusual and mysterious behavior instantaneously.

- A critical thinker: who has the ability to take charge of his thinking and presents focused and reflective decisions.

- Diverse in ideas: he should have diversity in perceiving, managing and solving tasks

- Rich in resources: he should have a number of information sources, tools, test data and connections with testing community to rely on when needed.

Figure.1 Factors that contribute to the tester's choice of exploration style [18].

In order to achieve and enhance the above mentioned properties of a skilled exploratory tester Kaner [14] suggests focusing on the learning strategies and tactics for effective exploration. To further guide the testers Andy Tinkham and Kaner state the learning styles of the testers [17]. The learning styles depend on a number of factors and based on these factors the decisions of the testers can be predicted. The different exploration styles of the testers are also discussed in [18]. An exploration style is an approach the testers adapt to fulfill a charter or a test mission. These approaches or exploration styles vary from tester to tester according to the situation and test scope. The factors contributing to the tester's choice of exploration style are mentioned in figure.1 above. Each style involves different set of questions. The ability to ask focused questions relies on the knowledge and skills of the tester. Details about exploration styles and learning styles can be study from [18] [17] respectively. The existence and need of such studies asserts the fact that testers are the most important factor for carrying out high quality exploratory testing.

B.3   Exploratory Testing Dynamics

The most recent contribution made to the subject of exploratory testing has been summarized in [25]. In this article the authors have argued against a common misconception towards exploratory testing approach. That common misconception is that "this approach is not very well structured". It is possible to adapt to the test situation at hand by making suitable selection from the list of work products mentioned in the article. Like other testing approaches exploratory testing technique can be applied to any testing technique. However it is quite important to select and redefine suitable work products according to the situation at hand. The process of redefining the work products outlined in [25] shall cause them to evolve into the artifacts that may aid in effective exploratory testing.

Exploratory testing makes optimal use of tester's skill and knowledge. In [et-dynamics] authors have chalked out a list of skills that are imperative for exploration of technology. It requires the testers to have a creative and imaginative approach towards the testing. That

can certainly help testers to come up with chiseled ideas. These ideas may include thinking about the product at hand as every one involved in the exploration activity should have a good idea about the customer's expectations. There are many considerations that you might want to keep in mind to evaluate someone else's testing. The list of considerations mentioned there-in is a compressed version of Satisfice Heuristic Test Strategy Model. If carefully selected from the list of consideration it is merely possible to be able to audit your exploratory testing.

Based on the suggestions made in the article you can structure your exploratory testing approach by:

- Making suitable selection from the work products.
- Knowing what skills are required.
- Evaluating your or some one else's testing.

This literature review was the basis of our understanding regarding ET. It was further used to construct study instruments for conducting interviews and survey.

APPENDIX C: DATA COLLECTION

This appendix presents the methodologies used for data collection. It also details the construction of all the study instruments used.

C.1   Study Methodology

We have used a descriptive case study for this investigation. The case study is designed to get the insight of the misconceptions and practices of exploratory testing in a real time industrial setting. The case study also intendeds to learn about exploratory testing from technical and customer perspectives. The advantages, disadvantages and adaptability of exploratory testing are primary concerns of the study.

Our methodology is qualitative and includes ten semi-structured interviews with industrial practitioners and a survey to further investigate and prioritize initial findings with a larger sample of 25 practitioners. The motivation of choosing qualitative methodology is due to the fact this research involves the study of human subjects and natural settings. Where as qualitative research is very well realized for providing methods such as case study and ethnography for an in depth and focused investigation [5]. Descriptive case study is said to be an empirical inquiry that investigates a phenomenon within its real-life context [12]. This was also one of the motivations for using case study. The motivation for selecting the semi structured interviews [25] is mainly due to the fact that they allow two way focused conversation which helps in attaining information apart from the questionnaire. Another reason is that the type of data collected from interviews can be either qualitative or quantitative [1]. As the questionnaire is a mix of both the types, semi structured interviews turn out to be a better choice for serving our purpose.

C.1.1   Construction of the Study Instruments (SI)

Four different study instruments were constructed. Study instrument 1,2,3 are the interview questions for interviewing three different perspectives at the case company. Study instrument 4 is a survey which was designed after the interviews. These study instruments were deigned to cover the entire study to answer all the research questions (see Appendix E). In order to construct the interview questions we conducted a thorough study of the relevant literature. After that we had carried out a brain storming sessions to decide upon the questions. Most of the questions are qualitative in nature while there are a few questions that shall return quantitative data as well. In all the interviews and the survey the reader will find some over lapping questions. This over lapping is done deliberately for studying the redundancy repetition of the information being collected. All the study instruments were checked by a researcher and an industry practitioner who had sound experience of research and ET respectively, in order to ensure the relevance and quality of the questions.

C.1.1.1   Study Instrument 1

Study instrument refers to interview questions designed for The interview questions were designed for studying exploratory testing in the industrial setting. The questions intend to cover the reasons, ways, advantages and disadvantages of using exploratory testing. They also intend to cover efficiency, effectiveness, planning, controlling, tracking, coverage and required training issues regarding this approach. The questions were both of qualitative and quantitative nature. To view the entire questionnaire, see Appendix F. Here you will find the questions and the rational of having these questions

C.1.1.2   Study Instrument 2

Study instrument 2 refres to the interview questions designed for ET skeptical testers. It was designed to investigate the reasons due to which, testers in the industry are skeptical about ET approach. Also to learn about the misconceptions they have regarding this approach. The questions are structured in a fashion that would investigate the following aspects respectively:

- Knowledge about ET approach.
- Perception of ET.
- Practice of ET approach
- Shortcomings of ET approach
- Benefits of ET approach
- Reasons for not using ET
- The scenarios where ET is considered not to be a suitable choice

C.1.1.3   Study Instrument 3

Study instrument 3 contains interview questions for ET customers. These questions were designed to investigate the perspectives of a customer or a manager regarding exploratory testing approach. They accommodated both exploratory testing supporting and skeptical customers. The same study instrument was sent to the participants who were unable to find time for interviews. The questions can be seen in appendix E.3.

C.1.1.4   Study Instrument 4

The study instrument 4 is the survey. The motivation of having this survey was to collect empirical evidences from a large sample of tester community, so that the analysis and results of this study could be generalized to some extent. More over exploratory testing is relatively a new area under discussion with little scientific research so we need the information provided by a number of industry practitioners in order to conduct a comprehensive research. The questions in the survey were taken from the questionnaire designed for ET supporting and skeptical testers. See Appendix E.4 for the survey.

C.2   Data Collection

To congregate the information for the case study; three ET testers and three ET skeptical testers at Sogeti were interviewed. The interviewees were working in the in house projects at Sogeti and were also providing their services as consultants to other organization. This was a plus factor as some of the empirical evidence being collected involved Sogeti and other organizations as well. The names of the organizations are not to be mentioned in the study. The investigation also involved 4 customers of Sogeti of which three of them supported ET and one of them was skeptical regarding ET.

One customer of Sogeti who supported ET was interviewed and the other four customers participated through emails due to unavailability of time. Following is the detailed manner for collection of the data from the three different data sources.

C.2.1   Selection of Participants

There were two types of participants selected for this study based on the study methods interview and survey.

1. Participants for interviews
2. Participants for survey

One of the motives of the study was to investigate ET from the testers and customers perspective. Therefore the participants were selected to accommodate each perspective.

	Tester	Customer
Exploratory Testing	Supportive (3)	Supportive (3)
	Skeptical (3)	Skeptical (1)

They were 10 participants of the interview and were further classified into four categories. Those are Testers having supportive and skeptical views regarding ET and then customers having supportive and skeptical views regarding ET. Table 1 illustrates the two perspectives and their sub categories. The number of participants of each perspective was not a deliberate choice. It was decided by the case company based on the following selection criteria.

o   Testers should have at least 2 years experience
o   Testers should have introductory training regarding exploratory testing.
o   Tester should have either of ET supportive or skeptical interviews.

On the other hand the selection criterion for customer was that the customer should have experience of working with exploratory testing. Other than that selection was performed by Sogeti and did not want to disclose any information regarding its customers.

The participants for the survey were selected through stratified convenience sampling. The stratum used for this sampling was "Tester". Stratum is the common characteristic that should be shared by the selected population. Sogeti network of employees was used to reach the tester population. We also used a public Swedish community of testers at www.testzonen.se to reach tester out side the customers Sogeti network.

C.2.2   Interviews

Semi structured interviews were conducted with a moderately open framework which allowed focused and conversational two way communication. The interview questions and their rationale are discussed in the detail (see Appendix E). The interviews were scheduled over telephone and a brief description of the study was presented to the personals before hand. The duration of the interviews was between 60 to 90 minutes per interviewee. Each interview was conducted individually. During the interviews brief written notes were taken and a tape recorder was used for future referencing for analysis purpose. The data from these sources were thoroughly studied to conclude over observations. At the end of each interview the interviewee was asked about the clarity and relevance of the question related to the topic. This was to make sure the interviewee understood the questions according to our anticipation.

C.2.3   Documentation Analysis

The record provided for documentation analysis was a "Test Plan" for one of the projects at Sogeti. A comprehensive study of the document was conducted. The test plan was very well cited with extensive details for each of its readers. The documentation was also viewed in contrast to the data collected from the interviews to see how well the test sessions were carried according to the plan. The other purpose of studying the documentation was to find out how well exploratory testing was documented and carried out. This was also to understand the differences it had as compared other traditional techniques specifically test case based testing. The documentation analysis also revealed how the test strategy was decided and based on what circumstances. The documentation analysis also included screen shots of the ET tool used for recoding information regarding the ET sessions. These screen shots elaborated in detail how the information regarding ET session was being stored and retrieved in the form of reports for later usage.

C.2.4   On site Participatory Observation

An on site participatory observation was conducted for a free style exploratory testing session. The participation in the testing session gave us the insight about free style exploratory testing session and its benefits. The testing session involved testing a new application on a mobile phone. The session started of with setting up the test mission. These activities involved setting up the test work products [25] such as testing tool, test mission, accessories used, and mission conducted by etc. After that the testing session was stared. We also participated in performing the testing. The test mission was to check all the common functionalities of the phone after integrating a new theme in the phone. The type of mobile device being used was a touch screen mobile. We quickly started opening the main menu then sub menu and so on carried on the check the functionalities of the phone. The noticeable thing here was that it was the very first time we were performing exploratory testing and on an application which was entirely alien to us but after being informed about test mission and test goals we managed to point out few issue during the testing session. When ever a bug or an issue was found its how, when and where were reported in the ET tool used for storing such information at Sogeti. At the end of the mission good enough information was submitted to the database using which comprehensive reports were retrievable. The screen shots of the ET tool are presented in appendix F.

C.2.5   Traceability study of instruments

This section presents the traceability of each research question in a tabular form. It shows for which research question which study instruments were used and what questions in the study instruments were used. It also shows the number of participant for each study instrument. This section also presents common and unique occurrences of each question in different study instruments.

Research question 1:

For research question 1, no specific study instruments were used. We conducted a literature review for this question

Research question 2:

TABLE 2 SHOWS STUDY INSTRUMNETS FOR RESERCAH QUETSION 1

Study Instrument	Questions	Number of Participants
SI 1	2,3,4	3
SI 2	6	3
SI 3	3,4,6	3

Research question 3:

TABLE 3 SHOWS STUDY INSTRUMNETS FOR RESERCAH QUETSION 2

Study Instrument	Questions	Number of Participants
SI 2	1,23,6,11,12,15	3
SI 3	5,7,8,9,14	4
SI 4	6,8	25

Research Question 4:

TABLE 4 SHOWS THE INSTRUMNETS FOR RESERCAH QUETSION 4

Study Instrument	Questions	Number of Participants
SI1	15,16,17,18	3
SI 2	7,8,9,10	3
SI 3	4,5	4
SI 4	4,5	25

Research Question 5:

TABLE 5 SHOWS THE INSTRUMNETS FOR RESERCAH QUETSION 5

Study Instrument	Questions	Number of Participants
SI1	13,14	3
SI 2	5	3
SI 3	10	4
SI 4	7,9	25

Research Question 6:

TABLE 6 SHOWS THE INSTRUMNETS FOR RESERCAH QUETSION 6

Study Instrument	Questions	Number of Participants
SI1	2,3,19,20	3
SI 2	12,13	3
SI 3	3,6,7	4
SI 4	2,3,6,7	25

C.2.6 COMMON AND UNIQUE QUESTIONS IN ALL STUDY INSTRUMENTS

The table below presents the common and unique question in all study instruments.

TABLE 7 COMMEN AND UNIQUE QUESTIONS IN ALL STUDY INSTRUMENTS

Type Instruments	Common/same Questions	Unique Questions
Interview for ET Supportive Tester	Q#1,15,16,17, 18,19,20	Q#2,3,4,5,6,7,8, 9,10,11,12,13, 14,21,22,23,24,25,6
Interview for ET Skeptical Tester	Q#7,8,9,10, 12,13	Q#1,2,3,4,5,6, 21,24,25
Interview for ET Customers	Q#4,5,2,10	Q#1,3,6,7,8,9,11 ,12,13,14,15
Survey	Q#1,4,6,5,9	Q#2,3,7,8

APPENDIX D: DISCUSSION AND CONCLUSION

This appendix contains the discussion, conclusion, future work and contribution to the current state of knowledge regarding this study.

D.1   Discussion

The purpose of this study was to investigate exploratory testing approach in an industrial setting. It aimed to investigate the misconceptions related to ET, while collecting evidence regarding its practices, pros and cons from its stake holder's perspective. It also intended to learn about adaptability and non suitability of ET in different areas and types of testing requirements. Combining ET with other testing techniques was part of the study as well.

The investigation began with conducting a comprehensive survey. But unfortunately, this approach relatively being a new topic lacked scientific research. We could not find much empirical evidences that supported the claims made in some of the pioneering studies such as [2][9][13]. Apart form the two Finish studies [7][8] and the a licentiate thesis [26] most of the literature found was from the books, articles and online resources by industry practitioners. Examples of online resources are lectures and articles available at Cem Kaner and James Bach's homepages, to name a few. Although the results of our study supports some of the claims made in them. The literature survey was the basis of our understanding regarding ET. We reviewed different definitions of ET. They depicted maturity and relatively better adaptation of ET approach over time. Initially ET approach was considered ad hoc testing mainly due to its comparison with structured testing techniques. Therefore, ET was stated to be an approach [1][14] not a technique. This was supposed to eradicate some of the misconceptions related to being ad hoc. But stating it an approach not a technique did not seem to be enough for the industry people to adapt it. Apart from all the stated benefits of ET [2][7][13], the industry seemed to be reluctant to adapt it. This according to our understanding was due to the lack of assistance and directives available for its effective usage. This specific reason was also stated by one of the ET customer we interviewed at our case company. In order to provide more structure to ET approach the manner of its usages was divided into different style, mainly free style ET and session based exploratory testing [9][13]. Free style was seen to be relatively less structured in terms of managing, controlling and tracking ET activities as compared to session based.

After the literature survey we conducted a descriptive case study in a single organization. After the case study a survey was also conducted in the industry. The survey was taken by a large sample of testers in the industry. This was done to map the results from the case study with a larger sample in the industry for generalization purposes. The case study initially investigated the practices of ET in the industry. The results of our investigation showed that the main purposes of using ET were, targeted testing, learning of the system and effective usage of testers ability and time. Our findings here support the claims made in earlier studies regarding the benefits of using ET. According to our findings Sogeti was using both types of ET at their company. But mostly used was session based. Therefore, we designed a Sogeti SBET framework in order to present the manner ET was being exercised in the industry. The framework detailed all the activities performed in session based testing. It highlighted the planning, execution, controlling, tracking and reporting aspects of SBT as practiced in Sogeti. The framework was also validated by

Sogeti but not in a formal manner. They reviewed the framework and gave positive remarks regarding its construction. Testers at Sogeti reported to use free style exploratory testing mainly to develop understanding of a new system under test. But they reported that free style ET is preferred to be used when the testers have developed their expertise in ET. This supports the claim that effective ET depends upon the skills and knowledge of the testers. Sogeti stated that it is ideal to use SBT with non ET expert testers.

The case study investigated the misconception related to ET approach in literature and industry as well. The misconceptions were studied from the testers and customers perspective at Sogeti. According to the best of our knowledge customer perspective of ET approach has not been discussed prior to this. From the result of our investigation it was evident that the customers in the industry did not have much knowledge regarding ET approach, its benefits and usage. They perceived it to be an ad hoc manner of testing and found it less credible for basing their decisions even using SBTM for ET. The most common misconceptions observed were; ET taken as technique rather than an approach and ET being prone to human errors. The misconception of the testers that ET is not preferred by customers was a true conception to some extent. This is stated according to our analysis based on the customer data. However it was specifically the case with ET skeptical customers. The other misconception of testers observed in Sogeti was that, the results of ET do not satisfy the customer. This claim was investigated in the industry by 25 other testers. 52.4 % of the participants in the survey stated that ET results were sufficient to satisfy the customers.

Pros and cons of ET were also explored in this study. The biggest advantage of ET stated by Sogeti was appropriate utilization of testers experience and knowledge. Where the testers in the survey stated that utilization of tester's creativity was the biggest advantage of ET approach. More or less the same view point. The biggest disadvantage reported by Sogeti testers was more prone to human errors. Whereas the testers in the survey stated difficulty of finding testers with appropriate experience, skill set and domain knowledge to be the biggest disadvantage. A major difference seen among the cons reported by Sogeti testers and industry testers was regarding the ET being prone to human errors. Sogeti testers thought it is whereas; industry testers disagreed with it largely. There could be several reasons for this. May be the testers in the industry were more skilled in ET as compared to testers at Sogeti and encountered less error made by human. According to our analysis we can say that if the problem stated by the survey participants is resolved to some extent. Then the problem stated by Sogeti testers can also be resolved to a certain degree, as effective ET results highly depend on the tester's skill and knowledge.

In this study we present a list of testing techniques used in combination with ET approach. The testers in the industry reported the preference of using ET in combination with other techniques. Risk based testing technique was most used in combination with ET approach at Sogeti. According to our analysis the effective combination depends on nature of software, complexity, design and customer requirements.

Apart from the main aims of the study we also investigated the challenges faced by industry regarding ET approach. The biggest challenge reported by all the participants was to make the industry realize the new role of tester in the testing activity, changing the mind set of people from the traditional approaches and try to remove the misconceptions related to this approach. Other challenges reported by the industry practitioners were to learn and be good at exploratory testing specifically regarding staying focused during testing sessions.

Another challenge identified by us regarding exploratory is to translate the tacit knowledge held by the testers during the testing session into explicit knowledge. Therefore we suggest that the testers should be explicitly trained for this conversation in order to make maximum use of this approach.

The restrictions related to ET approach were also explored. According to the participants of the study, the restriction of not implementing ET approach was mostly by the customers. When the customers were asked about this, they reported that ET only tells about how software fails and the testing progress in not evident. They accept that ET is useful and necessary but not sufficient, as it lacks in producing material on with decisions can be based. Whereas if ET is applied using SBTM, this claim seems to be weak. Because there are number of reports, metrics and graphical analysis available that are drawn from the logs and tools used for ET. These can be used to see the progress of testing, make predictions regarding the completion of testing and provide reports that can be used for making decisions [9].

According to our study and observing the practices of ET at Sogeti we have come to a conclusion that ET activity can be structured, accountable, auditable and able to generate reports if the testing activity is carried out in a structured fashioned, according to the requirements and understanding of what and why is being tested. The customers of Sogeti when questioned seemed to be very happy with the results ET was producing. This was specifically due to the fact that they being a customer knew where and for what they wanted to use exploratory testing.

Testers training aspect was also investigated in this study. Some of the practitioners deemed it necessary for the testers to be given initial training regarding ET. If not training then at least the concept should be communicated well with them.

Testing skills and domain knowledge were ranked at the top among the factors which were important in order to perform effective ET. Therefore these factors accompanied by domain knowledge were the characteristics searched in a tester for selection purposes.

Process improvement measures at Sogeti regarding exploratory testing were also discussed. According to the information provided, a lot of statistics apart from the mission reports were being maintained. Such as progress of a tester, reports being generated, contents of the reports and customer responses as well. All these statistics were monitored continuously and improvements were made consequently.

D.2   Conclusion

The goal of this study was to investigate the application and practices of exploratory testing in the industry. The literature survey revealed that although ET concept has gained better understanding over the period of time but still requires a lot of research and study of industrial practices to utilize the approach in a better manner. It also concludes that there is a lack or research on the use and effect of applying exploratory testing and a number of related claims need verification. A descriptive case study was performed in industry by conducting semi-structured interviews with six testers and four customers with different perspectives. They study of ET practices in the industrial partner resulted in session based exploratory testing framework. The framework divides all the activities in a test session into three phases that are session planning, session executing then finally session controlling and tracking. All activities are alienated and placed in each phase according to their chronological occurrence. During our investigation we encountered a number of opinions regarding ET approach which may or may not be considered as false impressions. We did not find any clear-cut reasons for either of the case. But most of the opinions depicted drawbacks of ET. The most common opinions about ET were that it is prone to human errors and it is conflicting whether ET is an approach or technique. For the first opinion it is hard to say if it is a misconception or not as we could not find any exiting research addressing this specific issue. On the other hand testers at the case organization stated this opinion as a setback of ET but this is not sufficient to state that it is a

misconception. More empirical evidence is required to affirm whether it is a misconception or not. In the case of second opinion we can state that it is a misconception. Because a number of studies in the exiting research, state and practice ET as an approach. The opinions of the ET customers at the case company were inability of ET to show testing progress, test coverage and results which could be used as decision material. Although the result from the survey shows that the testers in the industry think that ET is sufficient to satisfy the customers. The study also identified the claimed advantages and disadvantages of ET. The results collected from the interviews at the case company were further investigated by a larger sample of twenty-five industry practitioners. The prioritization shows that the major benefits of ET are appropriate utilization of tester's creativity, experiences and skills. On the other hand, the prominent disadvantages of exploratory testing are difficulty in finding testers with appropriate experience, skill set and knowledge. So we can conclude that industry lacks ET expertise which may be reason it refrains from its usage. It is also said to be less accountable and auditable than other testing techniques. The advantages stated by ET customers at the case company are effective in finding missed out bugs and ability to provide focused testing. ET is also found to be effective approach for testing continuously changing and unstable systems. The major disadvantage mentioned by the customers was inability to provide decision material. This drawback is earlier discussed as false impression of ET. This asserts our suggestion regarding the need of empirical evidence to separate the misconception from drawbacks. Learning of the system and performing targeted testing are the main purposes of using ET at the case company. Whereas, the most important reason for not using ET is dissatisfaction of customer with ET approach. Due to this it seems that restriction for not using ET approach comes from the customer. They may be due to customer's lack of knowledge or non suitability of ET with the testing requirements. According to the larger sample of practitioners ET is considered very suitable for situations where testing requirements are related to learning of the system and testing is time constrained. It is also considered very suitable for complementary testing. Conversely, ET is said to be unsuitable for testing critical systems. The results of the survey also showed that ET approach was preferred to be used in combination with other testing techniques. According to the results from the interviews and the survey in the industry ET is mostly used in combination with Risk based testing. In order to conclude we would like to say that extensive training of ET is required to increase its usage and see more factual impact of ET approach. Studies to gather more empirical evidences and insight of industrial practices are a must in order to provide clarity to different perspectives.

D.3   Future work
The aim of this thesis was to investigate ET approach in the industry. Therefore scope of the study was limited to providing results of the investigation. But during this study we identified a number of aspects which required attention and would assert the findings of this study in a better way. First and the foremost future work related to this study would be validating the Sogeti SBET framework at Sogeti and then evaluating its usage in a different organization. After this investigation, the suggested future work related to ET approach in general would be

- Studying ET misconceptions to find out if they really happen to be misconceptions or are disadvantages of ET
- Conducting a number of experiments in order to verify the pros and cons of ET
- ET requires studies where comparisons regarding the effective combinations with other testing techniques are made.

- Studies regarding the customer perspective on ET also seem to be important from the tester's viewpoint. Because this would help them improving there understanding regarding what the customer expects when ET is used.

D.4   Contribution to the current state of knowledge

Our study was an investigatory in nature. The investigation was not only in academia but also in the industry. This gives an insight how ET is being exercised in the industry. Our main contributions in this study is providing empirical evidences from the industry for the following

- List of identified purposes of using ET in industry. This shows the various situations ET is used in the industry for specific purposes to attain certain results.
- In this thesis we constructed a framework for ET in the manner it is being practiced in an industrial setting. This provides a practical example of ET that is being exercised in an organization.
- In this research we also incorporate the customer perspective on ET regarding its benefits, shortcomings and misconceptions. This is helpful in understanding the concerns customers have for using and not using ET.
- Our study also provides a list of testing techniques which are used in combination with ET for effective and useful testing.
- We have also investigated the types of requirements and areas the industry thinks ET can be adapted and also type of system and requirements where ET is not suitable.

APPENDIX E SURVEY AND INTERVIEWS

This section presents the questions for the interviews that were conducted and also the survey questionnaire.

The interview questions are designed for studying ET in the industrial setting. The questions intend to cover the reasons, ways, advantages and disadvantages of using ET. They also intend to cover efficiency, effectiveness, planning, controlling, tracking, coverage and required training issues. All the interviews started with general questions regarding

- Designation
- Testing experience
- ET experience

E.1   Interview Questionnaire For ET Supportive Testers

1. How would you describe your ET process?
2. In what scenarios do you use ET?
3. What are the reasons for using ET in the above mentioned scenarios?
4. Do you consider other options?
5. What type of ET approaches do you use and in what scenarios?
6. How do you plan and manage your ET activities?
7. How do you control and track your ET activities?
8. Do you maintain ET reports? If yes How?
9. Have you established ways for planning and prioritizing what to use ET for (coverage)?
10. Do you exercise any intentional test techniques and strategies for exploring?
11. Have you been able to identify and practice your own exploration style?
12. Do you implement free style ET, why and when?
13. What other techniques and methods do you use in combination with ET? When and why?
14. Do you use ET as a complementary testing technique as well?
15. What are the advantages of using ET?
16. Assign a weight to the following commonly recognized perceived benefits of ET from 0 to 100
   a. utilization of testers creativity
   b. utilization of testers experience and knowledge
   c. no pre designed documentation to follow
   d. simultaneous learning of system under test
   e. minimal or no preparation before performing testing
   f. focused testing
   g. more effective in terms of detecting important defects
   h. rapid feedback
   i. adapts well in rapidly changing situations
   j. add any additional
17. What are the disadvantages of using ET?

18. Weight the following shortcomings of ET from 0 to 100?

a. Difficult to track the progress of testers
b. Difficult to track the progress of test session
c. Traceability issues
d. Coverage issue (only selected parts can be tested)
e. More prone to human errors
f. Difficult to find testers with appropriate experience, skill set and knowledge
g. Less accountable and auditable

19. In what areas and types of testing ET is most suitable and why?
20. In what areas and types of testing ET is not suitable and why?
21. What are the challenges related to ET?
22. What are the restrictions of ET?
23. Do testers need or have to go through some training before performing or joining ET team?
24. Do you have any selection criteria for selecting testers for ET team?
25. Rank the following factors on the basis of importance in order for the tester to perform effective ET.
a. Testing Experience
b. Testing skills
c. Domain knowledge
26. Do you take any measures to improve the ET activity? What kind?

E.2   Interview Questionnaire for ET Skeptical Testers

This questionnaire is designed to investigate the reasons due to which, testers in the industry are skeptical about ET approach. Also to learn about the misconceptions they have regarding this approach. The questions are structured in a fashion that would investigate the following aspects respectively:

• Knowledge about ET approach.
• Perception of ET.
• Practice of ET approach
• Shortcomings of ET approach
• Benefits of ET approach
• Reasons for not using ET
• The scenarios where ET is considered not to be a suitable choice

Interview Questions

1. What do you know about ET approach?
2. Can you explain ET in your own terms?
3. Do you take ET as an approach or technique?
4. Have you ever used ET specifically?
5. Have you ever used testing techniques in an exploratory manner for achieving a test goal?
6. What are the reasons for not using ET?
7. Can you list some perceived shortcomings of ET approach?
8. Assign any weight from 0 to 100 in terms of significant shortcoming of ET approach. Where 100 being the most and 0 being the least significant. Total sum of all should be 100.
a. Difficult to track the progress of testers

b. Difficult to track the progress of test session and/or whole testing progress.

c. Traceability issues

d. Coverage issue (only selected parts can be tested)

e. More prone to human errors

f. Difficult to find testers with appropriate experience, skill set and knowledge

g. Less accountable and auditable than traditional testing techniques.

9. Can you list some perceived benefits of ET approach?

10. Assign any weight from 0 to 100 in terms of importance to the following perceived benefits of ET approach. Where 100 being the most and 0 being the least important. The total sum should be 100

a. utilization of testers creativity

b. utilization of testers experience and knowledge

c. no pre designed documentation to follow

d. simultaneous learning of system under test

e. minimal or no preparation before performing testing

f. focused testing

g. more effective in terms of detecting important defects

h. rapid feedback

i. adapts well in rapidly changing situations

j. add any additional

11. Can you rank the following into not important, important, very important and most important reasons for not using ET approach?

• Perceived shortcomings of ET approach

• The customer is not satisfied with using ET approach

• The type of system under test

• Lack of knowledge about ET approach

• Little knowledge about benefits and effects of ET

• ET concept is new and lacks in depth research.

12. What type of customer requirements, ET approach in not a suitable choice?

13. What type of projects or systems you think ET in not suitable for?

14. Do you think it is difficult to have tool support for ET approach?

15. Have you ever used ET approach in your individual tasks? If yes, then in what scenarios?

E.3 Questionnaire for ET customers

These interview questions are asked form the customer organizations which are using exploratory testing. The same questionnaire was presented to the customers who are skeptical towards ET approach.

Interview Questions

1. Would you like to elaborate a little about how you buy your testing services?

2. What do you think about ET approach and why should it be practiced?

3. When and why do you select ET approach?

4. What benefits do you find in using ET approach?

5. What shortcomings do you find in using ET approach?

6. When do you find ET the most appropriate choice and why?

7. When do you find ET inappropriate choice and why?

8. Do you find ET approach auditable?

9. Is it easy to track testing progress with ET approach?

10. Do you use ET as complementary approach to other testing techniques?

11. In comparison to what other techniques, do you find (if you find) ET approach more effective and efficient and when?

12. Is it easy to find experienced and skilled exploratory testers?

13. Do you think ET approach lacks scientific research?

14. Why do you think Industry is a little skeptical about ET?

15. Do you think it is hard to find experienced testers for exploratory testing?

E.4   Industry Survey

This section presents the questionnaire which was used for industry survey.

Exploratory Testing

1. Survey Motive

Exploratory testing approach has gained focus of the industry practitioners and researchers in the Software engineering community.This survey is also being conducted for research purposes. The motive of this survey is to understand the exploratory testing approach from different perspective. How exploratory testing is perceived and adapted in the industry.

All in the information provided in the survey is subject to privacy and would be used for research purposes only. Any information regarding the participants will not be published or revealed.

2. Participant Information

* 1. Please provide your Name, Designation and Testing experience

3. Questionnaire

* 1. Can you briefly describe your understanding of the Exploratory Testing approach?

* 2. Have you ever used exploratory testing for any of the following? Also mention if you have used it for any other scenario.

- è Complimentary testing
- è Learning of the system
- è Targeted testing
- è Test Driven Development
- è Testing under time constraints

Other (s)

Exploratory Testing

* 3. When do you think exploratory testing is most useful?

- ê When the software is untested

- ê When the software is stable

- ê When the software is unstable

- ê When the software is tested

Other (please specify)

[   ]

* 4. Assign any weight from 0 to 100 in terms of significant shortcoming of ET approach. (100 $ test)Where 100 being the most and 0 being the least significant. Total sum of all should be 100.

Coverage issue (only selected parts can be tested)	[ ]
Difficult to track the progress of test session and/or whole testing progress.	[ ]
Difficult to track the progress of testers	[ ]
Traceability issues	[ ]
Difficult to find testers with appropriate experience, skill set and knowledge	[ ]
g. Less accountable and auditable than traditional testing techniques.	[ ]
More prone to human errors	[ ]

* 5. Assign any weight from 0 to 100 in terms of importance to the following perceived benefits of ET approach. Where 100 being the most and 0 being the least important. The total sum should be 100. (100 $ test)

focused testing

utilization of testers creativity

more effective in terms of detecting important defects

simultaneous learning of system under test

no pre designed documentation to follow

utilization of testers experience and knowledge

minimal or no preparation before performing testing

rapid feedback

adapts well in rapidly changing situations

* 6. What type of software testing do you think exploratory testing is suitable and not suitable for?

* 7. How do you prefer using exploratory testing approach?

- As a complimentary technique

- solely exploratory

- In combination with other techniques

- Using other techniques in an exploratory manner

Reasons (please specify)

Exploratory Testing

* 8. Are the results produced by exploratory testing sufficient to satisfy the customer and management to take decisions

ʃ∩ Yes, why

ʃ∩ No, why

ʃ∩ Other (please specify)

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* 9. Which other testing methods can ET be effectively combined with

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APPENDIX F: SCREEN SHOTS OF ET TOOL BEING USED AT SOGETI.

This section contains the screen shots of the ET tool being used at Sogeti.

F.1   Main Menu

The output of this research would be a detailed report consisting of the following outcomes:

  • A detailed analysis of what ET is according to the literature and industrial practitioners. A comprehensive definition of ET.

  • A procedure or approach that is being practiced in the industry.

  • A list of most common misconceptions related to ET and the rational behind them.

F.2   New Mission

F.3   Mission

F.4   Interactions

F.5   Statistics

F.6   Week Report

APPENDIX G: SAMPLE TEST SESSION REPORT

This is an example of session report generated at the end of a test session according to SBMT by Jonathan Bach [9]. This report is to illustrate an example of a session sheet and also to know the contents being stored in the session sheet.

```
CHARTER
--------------------------------------------------
Analyze MapMaker's View menu functionality and report on
areas of potential risk.
#AREAS
OS | Windows 2000
Menu | View
Strategy | Function Testing
Strategy | Functional Analysis
START
--------------------------------------------------
5/30/00 03:20 pm
TESTER
--------------------------------------------------
Jonathan Bach
TASK BREAKDOWN
--------------------------------------------------

#DURATION
short
#TEST DESIGN AND EXECUTION
65
#BUG INVESTIGATION AND REPORTING
25
#SESSION SETUP
20
#CHARTER VS. OPPORTUNITY
100/0
DATA FILES
--------------------------------------------------
#N/A
TEST NOTES
--------------------------------------------------
I touched each of the menu items, below, but focused
mostly
on zooming behavior with various combinations of map
elements displayed.
View: Welcome Screen
Navigator
Locator Map
Legend
Map Elements
Highway Levels
Street Levels
Airport Diagrams
Zoom In
Zoom Out
Zoom Level
(Levels 1-14)
Previous View
```

Risks:
- Incorrect display of a map element.
- Incorrect display due to interrupted repaint.
- CD may be unreadable.
- Old version of CD may used.
- Some function of the product may not work at a certain zoom level.
BUGS

#BUG 1321
Zooming in makes you put in the CD 2 when you get to a certain level of granularity (the street names level) -- even if CD 2 is already in the drive.
#BUG 1331
Zooming in quickly results in street names not being rendered.
#BUG <not_entered>
instability with slow CD speed or low video RAM. Still investigating.
ISSUES

#ISSUE 1
How do I know what details should show up at what zoom levels?
#ISSUE 2
I'm not sure how the locator map is supposed to work. How is the user supposed to interact with it?

REFERENCES

[1] Tinkham, A., & Kaner, C. "Exploring Exploratory Testing". Paper presented at the STAR East 2003 Conference, Orlando, FL, USA. Visited 2009 09 21http://www.testingeducation.org/articles/exploring_exploratory_testing_star_east_2003_paper.pdf

[2] Bach, J., "Exploratory Testing", chapter in The Testing Practitioner, Second ed., E. van Veenendaal Ed., Den Bosch: UTN Publishers, 2004, pp. 253-265.

[3] C. Kaner, J. Bach and B. Pettichord," Lessons Learned in Software Testing" , New York: John Wiley & Sons, Inc., 2002.

[4] C. Kaner, J. Falk and H.Q. Nguyen, "Testing Computer Software", New York: John Wiley & Sons, Inc., 1999

[5] Creswell J, "Research Design: Qualitative, Quantitative and Mixed Method Approaches". Sage Publications Ltd, 2002.

[6] IEEE, "Guide to the Software Engineering Body of Knowledge", IEEE, Tech. Rep. IEEE - 2004 Version, 2004

[7] Itkonen, J. and K. Rautiainen. "Exploratory Testing: A Multiple Case Study", in Proceedings of the International Symposium on Empirical Software Engineering (ISESE 2005), pp. 84-93, 2005

[8] Itkonen, J., M. V. Mäntylä and C. Lassenius. "Defect Detection Efficiency: Test Case Based vs. Exploratory Testing", in proceedings of the International Symposium on Empirical Software Engineering and Measurement, pp. 61-70, 2007.

[9] J. Bach. "Session-Based Test Management", STQE, vol.2, no. 6, 2000.

[10] L. Copeland, "A Practitioner's Guide to Software Test Design", Boston: Artech House Publishers, 2004.

[11] R.D. Craig and S.P. Jaskiel, Systematic Software Testing, Boston: Artech House Publishers, 2002.

[12] R.K. Yin, Case Study Research: Design and Methods, London: SAGE Publications, 1994

[13] Bach J., "Exploratory Testing Explained", Published as a chapter in The Test Practitioner, 2002. Visited 2009 08 20, http://www.satisfice.com/articles/et-article.pdf

[14] Cem Kaner & James Bach, "The nature of exploratory testing." Lecture at Tampere, Finland, May 7, 2004.

[15] Lyndsay, J. "A positive view of negative testing", Workroom Productions Ltd. March 19, 2003. http://www.workroom-productions.com/papers/PVoNT_paper.pdf.

[16] Lyndsay, J. and N. van Eeden. "Adventures in session-based testing". Workroom Productions Ltd. May 27, 2003. http://www.workroom-productions.com/papers/AiSBTv1.2.pdf.

[17] Tinkham, A and Kaner. C,"Learning styles and exploratory testing". Pacific Northwest Software Quality Conference, 2003.

[18] Kaner, C. "A Course in Black Box Software Testing", 2002, Summer (Professional Version), 2003, from http://www.testingeducation.org/coursenotes/kaner_cem/cm_200204_blackboxtesting/

[19] Hazzan, Orit & Dubinsky, Yael . "Agile Software Engineering". Undergraduate Topics in Computer Science, Springer, 2008

[20] C. Wohlin, P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell and A. Wesslén, "Experimental Software Engineering -- An Introduction", Kluwer Academic Publishers, ISBN 0-7923-8682-5, 2000.

[21] Mark, Scott. "Test-Driven Development: An Agile Practice to Ensure Quality is built from the Beginning". Ioannis G.Stamelos & Panagiotis Sfetsos: Agile Software Quality Assurance, 2007. Information Science Reference.

[22] Pettichord, Bret 2002. Agile Testing – What is It? Can it Work?, Online, Visited 2009.09.30 http://www.io.com/~wazmo/papers/agile_testing_20021015.pdf

[23] Myers, G. J. "The Art of Software Testing", John Wiley & Sons, New York, 1979.

[24] Kalman, Sam, "Session-Based Test Lite." Quardev Laboratories. May, 2007, Visited 2009 10 05 http://www.quardev.com/content/whitepapers/SBTMLite_samkalman.pdf

[25] James, Jonathan Bach "Exploratory Testing Dynamics" Visited, 2010 01 02 http://www.satisfice.com/articles/et-dynamics.pdf

[26] Itkonen, J. "Do test cases really matter? An experiment comparing test case based and exploratory testing". Licentiate Thesis. Helsinki University of Technology, 2008